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FOAM EXTRUSION

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NEW HORIZONS IN VINYLS, AND PLASTICS IN THE SHOE INDUSTRY, TECHNICAL CONFERENCE... page 743

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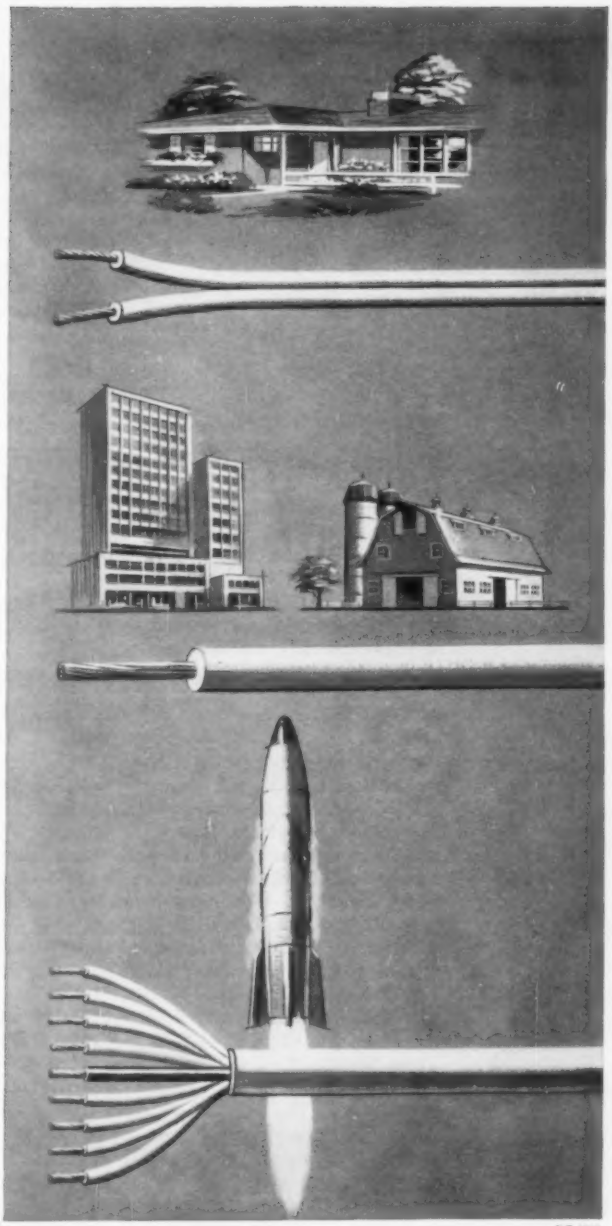

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Also available

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The Cover

One of the most promising processes for making foam-right in the extruder-ana continuously, is highlighted in this month's SPE Journal. The cover shows the product. The chemistry, engineering, and applications are detailed on page 705·

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EDITORIAL

The Engineering Approach

A visitor to our office one day last month was discussing new plastic materials, and particularly their application in engineering uses. He asked the question, "Is there a trend away from the empirical approach in developing new applications?" The answer to this question is an emphatic yes. As a matter of fact, it is one of the significant trends which is changing the complexion of the plastics industry. Where guesswork was once the norm, equations are now the accepted thing. Where weathering and chemical resistance were once prognosticated, solid data is available, citing years of correlative tests.

The plastics industry is characterized by a rapid rate of technological development. For proof, just think for a minute about the new plastics and modified types that have been introduced in the past twelve months. To extend this technology into the areas of use seems only logical. To make the potential user of plastics materials confident about those materials is entirely fitting. Several months ago, an article describing an engineering approach to designing with plastic parts was published in the SPE Journal. The response from companies not now manufacturing with plastics indicated that this is what they are waiting for—engineering data that they can use in designing with confidence. Thus, time and technology have answered the complaints of those critics of the plastics industry who, in the past, have said that this industry was too ambitious in reaching for markets in which its products were not entirely suited.

Another approach to developing applications based on sound engineering judgment is closer liaison with other industries. Our friends in England are active in promoting joint programs through which technical knowledge is shared. In a recent issue of the British magazine Plastics, for instance, it was suggested that joint programs be undertaken between the Plastics Institute and the Royal Institute of British Architects. The idea is a good one and should be encouraged in this country.

Scientific progress in the development of materials must be accompanied by applications based on engineering principles. John Tyndall, English physicist, once said, "The brightest flashes in the world of thought are incomplete until they have been proved to have their counterparts in the world of fact." The use of engineering principles in developing new applications does just that for scientific progress in the field of plastics materials.

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Your local Section activities, RETEC meetings and Journal issues already planned for this Fall, are so important to you and the future of plastics engineering, that you as a member cannot afford to miss any of these valuable programs.

Your Council recently voted to amend By-law B-15 as follows: "90 days after membership invoice dues notice has been mailed, a member will be dropped if payment of such dues has not been received by the national office".

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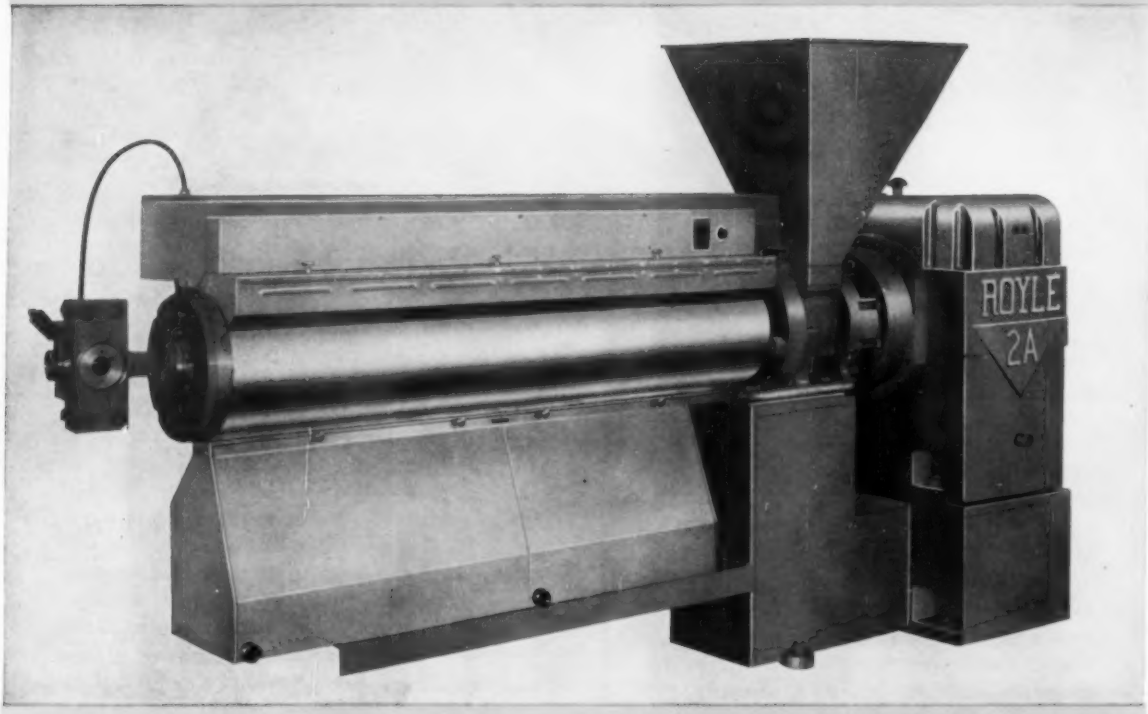

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A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

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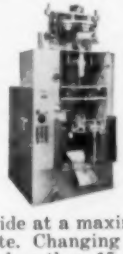
Lamination of 300-gauge cellophane and 2-mil polyethylene is used for low-cost, single-use package that is both a container for two aspirin tablets and a drinking cup. Heat sealing divides the package into its two compartments – upper for tablets, lower for drinking cup. It has a tear opening.

Polyethylene shower caps that double as a carrying case for damp swim suits, cosmetics and other small articles are being supplied by hotels and motels as a complimentary convenience item for guests. They can be printed with a stock or special merchandising message.

A new machine offering wide range size and high-speed automatic bag forming, filling and sealing, has recently been announced. The machine is said to be especially adapted to pouch packaging of frozen vegetables and candy products in polyethylene. It forms bags from 3" to 15" long and 2" to 8½" wide at a maximum rate of 75 per minute. Changing bag size is said to require less than 15 minutes.



Special laminates of thin aluminum foil glue-bonded to paper, with a polyethylene coating on the foil or paper, have been developed by an English company to protect phonograph records from warping when shipped in hot and humid climates. Bags made of these materials are superior to polyethylene bags alone, which, although fine for temperate conditions, may be inadequate for tropical areas because of moisture vapor penetration.

The bags are produced by folding a section of laminate in half, heat sealing the sides, inserting the record and sealing the opening. The metallic or paper outside can be printed, or the moisture-protective bag inserted into a printed over-wrap polyethylene bag.

Miniature polyethylene containers, with a hinged shaker cap permitting one-hand opening and closing, are now being used for salt and pepper—at a cost equivalent to that of paper. Body, shaker cap and lid with interlocking nib are injection molded in one piece. Bottom of the 1⅜" container is foil-laminated disk. Filling rate, controlled by printing speed, is 200 units per minute. The containers are sold in stores in tray packs of six for salt, three for pepper.

Consumers Prefer Polyethylene Wrap For Dry Cleaning and Laundry

Appeals of Flexible Containers Also Listed in Consumer Survey

In a recent survey, consumers showed a marked preference for polyethylene laundry and dry cleaning wraps; said "noiselessness", transparency, break resistance and light weight are the most appealing properties of flexible polyethylene plastic containers; and listed book covers, packaging for liquids and toothpaste tubes as the leading items "which should be made of plastic".

The survey, conducted by a market research company for U.S.I., queried a 1,300-member consumer panel to determine how they felt about polyethylene products and why. The panelists represent a cross section of consumers in seventeen major cities from coast to coast.

72% for Polyethylene

According to the survey, 72% of the panel preferred their dry cleaning and laundry wrapped in polyethylene film rather than in other wraps. High on the list of reasons for this preference to polyethylene wrap is transparency, closely followed by protection against dust and water. Other advantages cited over competitive wrapping materials are ease of storage, strength, and better appearance.

U.S.I. further learned that 70% of the participants in the survey receive their dry cleaning and laundry in polyethylene. This indicates that consumer preference for polyethylene is actually somewhat greater than the polyethylene wrapping service now being offered by cleaners and laundries.

Squeezable Over Rigid

In selecting the most appealing aspects of flexible polyethylene containers, 79% of the panelists mentioned the "noiselessness" of such containers as the basis for preference over the same item made of rigid plastic. Other scores in favor of polyethylene were: transparency 71%; break resistance 66%; and light weight 52%.

The choice of "noiselessness" as the leading property is significant in designing products to be used in hospitals, rest homes and private dwellings. Applications such as garbage cans and most houseware items are in this category.

Transparency, protection from dust and water, ease of storage, strength, better appearance, were reasons respondents to survey gave for preferring their cleaning and laundry packaged in polyethylene.

New Plastics Uses

Many of the suggestions consumers gave for items they'd like to see made of plastic can be, or already are being made of polyethylene, either alone or in combination with other materials. Examples are jelly containers, household cleaner bottles, toothpaste tubes and bread wrap. The latter use has caught on rapidly with bakers and offers, according to U.S.I. estimates, a 60 million pound potential to film producers in five years. Among other items listed were packages for liquids, milk carton coating, and thread spools. Of these, polyethylene for coating milk cartons alone represents a potential market for 110 million pounds of polyethylene.

The wide range of these survey suggestions indicates an awareness by consumers of the role of plastics in daily life and their value in improving familiar household products.

Hospitals Fight Cross-Infection With Polyethylene-Coated Bags

Bags with a polyethylene-coated inner ply are being used in key locations in a paper and sack holder disposal system being installed in a number of hospitals in Great Britain. The system, aimed at cutting cross-infection, uses color-coded bags for disposal of soiled linen, dry refuse, kitchen waste, and soiled dressings. Filled bags are sealed before transporting to a location where they are sorted without physical contact with contents, and sent to the laundry or incinerator. Polyethylene-coated bags are used where most waste is involved, such as in operating rooms and the kitchen.

In addition to hospitals, the sack system is being used in factories, restaurants and municipalities for refuse collection and for collection of litter at public places. Advantages cited include hygienic disposal, ease of handling, flexibility of use.

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POLYETHYLENE PROCESSING TIPS

BLOW MOLDING: SELECTING BEST POLYETHYLENE RESIN, OPTIMUM OPERATING CONDITIONS

The objective of any blow molding job is to make the best product possible most economically. To achieve this objective, resin properties and machine conditions, as well as mold cycle time, have to be considered.

The properties sought in the molded product, of course, depend on its intended application. In each case, the molder must consider the relative importance of these factors: stiffness, appearance, gloss, wall uniformity, weld line, parting line, stress crack resistance.

A product's end use determines whether it must be stiff or flexible. For most products, good appearance – high gloss, smooth surface, no flow lines – and durability are required. Uniform wall thickness, strong weld lines and parting lines with the same gauge as the walls are also desired.

Although gloss is considered a requisite for good appearance, it is listed as a separate property here because there are a number of applications in which low gloss is required. Other products may not need high stress crack resistance which may be sacrificed to some degree to improve other properties.

Mold Cycle Time

The molder must also consider mold cycle time – a most important factor in production costs. Obviously, the shorter the cycle, the more economical the process. But here again, other prerequisites must be considered and a balance struck.

Variables Affecting Properties

Table 1 shows the effect of an increase in resin density and melt index and extrusion and molding factors on the properties of the molded piece. Although the information listed has been obtained by extrusion-blow molding 4 oz. Boston round bottles, it generally holds true for all extrusion-blow molding processes within the ranges shown.

The blow molder can use this table to determine which variables should be adjusted to improve a given property. Also he can learn which properties are favorably or adversely affected when resin density and melt index or extrusion and molding conditions are adjusted. Table 1, therefore, is a useful guide for selecting the most suitable resin and adjusting machine conditions to obtain the desirable balance of end product properties.

Table 1 Effect of Resin, Extrusion, and Molding Factors on Bottle Properties and Output [1]

Increase in these factors affects these properties →		Resin Properties		Extrusion Conditions			Molding Conditions		
		Density	Melt index	Melt temperature	Annular die clearance	Extrusion rate	Mold temperature	Mold time	Blow pressure
Bottle properties	Stiffness	Large increase	NSE	NSE	—	Slight decrease	—	—	—
	Stress crack resistance	Decrease	Large decrease	—	—	—	—	—	—
	Gloss	Large increase	Increase at 0.915 density No effect at 0.932 density	Increase	NSE	—	NSE	Increase	NSE
	Appearance [2]	Improvement	NSE	Slight improvement	NSE	NSE	Improvement	Improvement	Large improvement from 10 to 50 lb/sq in. NSE from 50 to 80 lb/sq in.
	Wall uniformity	NSE	NSE	Slight decrease	Decrease	NSE	Slight decrease	NSE	
	Weld-line thickness (strength)	Large decrease	NSE	NSE	Large increase	NSE	NSE	NSE	Large increase from 10 to 50 lb/sq in. No effect from 50 to 80 lb/sq in.
	Parting-line difference	NSE	No effect at low blow pressure Large increase at high blow pressure	Slight increase	NSE	NSE	Increase	NSE	Large increase
Mold cycle time		Large decrease	NSE	Increase	Increase	—	Large increase	Large increase	NSE
Range of tests limited to →		0.915 to 0.932 g/cu cm	1.5 to 4.7 g/10 min	350 to 340 °F	54.5 to 79.5 mil	0.2 to 0.4 in./sec	60 to 140 °F	12 to 24 sec	10 to 80 lb/sq in.

NSE – no significant effect

1) tests on 4-oz Boston round bottles

2) qualitative rating of gloss, surface smoothness, and flow lines in bottle

Table 2
PETROTHENE® Resins for Blow Molding

			RATINGS					
PETROTHENE	Density	Melt Index	Stiffness	Melt Flow	Stress Crack Resistance	Fast Cycle Time	Overall Appearance	Bottle Application
101*	0.924	2.0	5–	4–	4	4–	5	up to 32 oz.
102-2*	0.924	2.0	5	4	4–	4	5	up to 32 oz.
209-2*	0.920	3.0	4	5	3	5	5	up to 16 oz.
301	0.916	1.0	4	3	5	3	4	all sizes

*Technical data sheets available.

Table shows the relative rating of each resin in each category listed. The highest numerical rating indicates the best resin in each category.

Blow Molding Resins

Table 2 lists four PETROTHENE® resins which are suggested for blow molding. Of these, PETROTHENE 101, 102-2 and 209-2 represent the latest U.S.I. developments in the blow molding field.

U.S.I. has prepared a technical data brochure on blow molding, containing detailed information obtained in the course of an elaborate research program. Ask for a copy. Technical data on other areas of interest to blow molders not yet investigated will be released as soon as available. For information in these areas, or for assistance on any aspect of blow molding, contact the U.S.I. Sales Office nearest you.

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SPE JOURNAL NEWSLETTER

reading time
1 minute

New SPE Publication

At a meeting in Cleveland in May, Council gave the go-ahead on a new SPE publication to be called SPE Transactions. Plans call for initial publication in January 1961. The new journal will be published quarterly and will contain articles of a fundamental nature related to plastics science and engineering.

Flame-Resistant Urethanes

Polyether-type urethane foams can be made flame-resistant by adding tris (beta-chloroethyl) phosphate (TCEP) to the foam mix. With high concentrations of TCEP, the foam can be made completely self-extinguishing. The development is of considerable significance since the cheaper polyether foams are harder to flame retard than polyesters—opening up new applications for the flame-retarded polyether foams.

New Polymerization Study Tool

A method for studying polymerization rates of thermosetting polymers, utilizing electrical resistivity measurements has been developed. It should be useful in determining rates of polymerization as well as the extent of polymerization. Another use: Evaluating reactivity of crosslinking catalysts.

Porous Plastic Laminates

Research workers at the U. S. Army's Walter Reed Medical Center have developed a method for making homogeneously porous and complex-shaped plastic laminates. The layered fabric-resin composite is made by stretching a polyvinyl alcohol film over an aluminum mandrel, covering this with a nylon stockinet, and pulling another polyvinyl alcohol "bag" over this. The laminate is then encapsulated with epoxy resin.

Plastics Engineers Graduated

Lowell Technological Institute graduated six men with bachelor of science degrees in plastics engineering on June 5. Biggest employer was the Military, although Du Pont, American Cyanamid, and Enjay each hired a newly-graduated plastics engineer.

Super Laminates

Digital computers are now being put to work to predict optimum layer orientation for glass reinforced plastic laminates. The equations which make computer use possible were developed by research engineers at Grumman Aircraft Co. Two practical offshoots of the computer work could be superstrength laminates and a method for predicting laminate failure .

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SPECIAL FEATURE

Maintenance of Compression and Transfer Molding Equipment

For maximum plant efficiency, curb the natural tendency to do maintenance of equipment on Saturdays only, and initiate a system of regular and periodic maintenance

A Staff Feature

Maintenance of compression and transfer molding equipment is somewhat different than maintenance of injection molding equipment (covered in the June issue) and maintenance of extruders (covered in May). Reason for it is the fact the most of the equipment is much older. Compression molding has been around much longer. As a result, maintenance in many companies, especially in custom molding plants becomes a matter of fixing, modifying, and keeping the old machines running. However, even in the oldest of compression molding plants, a systematic program of planned maintenance offers great reward for time and effort spent on this activity. And in the plants operating with the newest automatic equipment, maintenance is simply the protection of a valuable capital investment.

Initial Installation

The ideal floor is concrete, however any sufficiently sturdy wooden floor is also satisfactory. Machines should be spaced far enough apart so that there is not too great a loading on a given floor area. A helpful idea in the initial installation stage is to place, permanently, sheetmetal pans under each machine. These pans distribute the machine load over a greater floor area and at the same time serve as an oil drip pan preventing the oil from soaking into the floor and leaking on to the floors below. Where machines are located on upper floors, and if the floor is wooden, it may take considerable time for the wood to become saturated and for the oil to seep through to the floor below giving evidence of the leak. When the pans are placed under the machines oil leaks become immediately apparent."

Editor's Note

This is the last of a three-part series on maintenance of equipment in the plastics industry. In May, maintenance of extrusion equipment and an extruder's check-list were published. Maintenance of injection molding equipment was covered in June. Reader response to both articles was very enthusiastic, indicating the high degree of interest in a subject that molders and extruders know is important—but often neglected in plants operating at peak capacity.

Copies of this article, including the maintenance system for pinpointing down time (page 683) and the check-list (page 684) are available at $0.50 each, 50 copies—$15.00, and 100 copies—$25.00. Address orders to SPE Journal, 65 Prospect St., Stamford, Conn.

Careful Starting Procedure—Good Preventive Maintenance

Compression molding machines, especially automatics, can be started with a minimum of activity. But careful thought to a number of details, prior to starting, can prevent damage or operating difficulties later. Of great importance is the proper kind and right amount of hydraulic oil. Oil level should be checked through the sight glass. Rotation of the motor should be checked, after which the machine should be dry cycled for about 30 minutes.

Before installing the mold, it should be checked to make sure that heater and thermostat bulb will fit properly Heaters should be checked for continuity with a portable ohmmeter. In addition, some maintenance specialists check the heaters by touching very lightly with a finger. **Caution**: If you use this method, do it rapidly and with the full knowledge that heaters are hot.

Different runs require different press speeds. During this initial dry run, the hydraulic valves should be adjusted to give the right press speed for a particular job. After the mold is placed in the machine, check to make sure that it fits properly and that the dies align properly. Tie rods should be tight (check tie rod nuts on top) and cylinders should be inspected for leakage of hydraulic fluid.

A Maintenance System for Pinpointing Causes of DOWN TIME

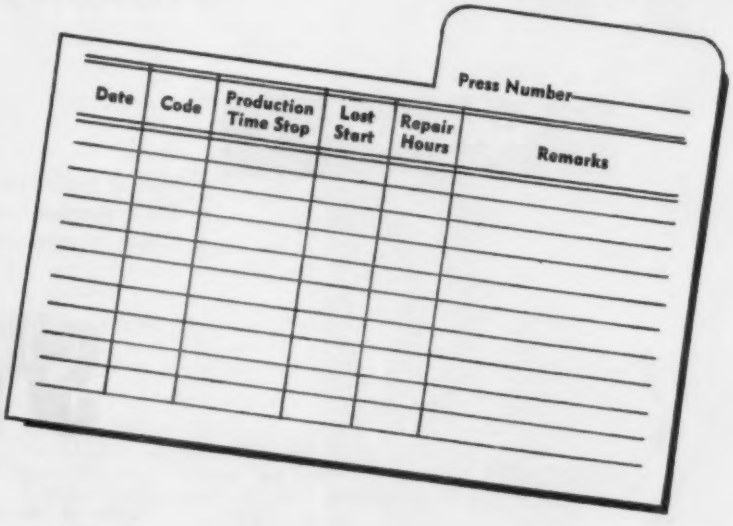
Here's how the system works. The maintenance guide below is kept in the molding office. When a machine is shut down, using the guide, the code number corresponding to the reason for shut down is entered on a card (sample below). There is a card for each machine. Other information, such as date, how long it took to repair, etc. can also be entered on the card at the same time. At the end of the month, the cards should be collected and examined for chronic maintenance problems or frequent causes of shut down. With such causes pinpointed, remedial maintenance can be started. A list of some of the most frequent causes of down time and numerical code numbers which can be used on the cards follows:

Code	Reason for Shut Down
	MOLD RUN STOPPED
1.01	Order Complete
1.02	Comb'n. Mold-Change Part Nos.
1.03	Out of Material
1.04	Material Not Uniform
1.05	Mold To Repair
1.06	Other (Write In)
	PRESS REPAIR (HYDRAULIC)
2.01	Oil Leak—Pipe Connections
2.02	Oil Leak—Packings
2.03	Pump Failure
2.04	Pressure Regulator
2.05	Water Regulator Failure
2.06	Oil Change
2.07	Other (Write In)

Code	Reason for Shut Down
	PRESS REPAIR (ELECTRICAL)
3.01	Solenoid Failure
3.02	Micro Switch Failure
3.03	Grounded Circuit
3.04	Motor Burn Out
3.05	Circuit Breaker Failure
3.06	Temperature Control Failure
3.07	Timer Failure
3.08	Control Switch Failure
3.09	Fuse Failure
3.10	Burned Out Heaters
3.11	Other (Write In)
	PRESS REPAIR (MECHANICAL)
4.01	Toggle Wear
4.02	K. O. Mechanism
4.03	Loading Board & Comb Plate
4.04	Shear Pins

Code	Reason for Shut Down
4.05	Air Valve Failure
4.06	Comb Plate Brackets
4.07	Cam Bracket
4.08	Other (Write In)
	REASON FOR CONDITION
A.	Worn Out
B.	Scored Parts
C.	Defective Material
D.	Loose Connections
E.	Voltage Regulation
F.	Vibration
G.	Overload
H.	Improper Setup
J.	Improper Lubrication
K.	Improper Cleaning
L.	Improper Material
M.	Other (Write In)

Sample DOWN TIME Card



Copies of this maintenance system and Check-List (page 684) may be obtained from SPE Journal, 65 Prospect St., Stamford, Conn. Single copies $0.25, 50 copies $8.00, 100 copies $12.00.

CHECK-LIST for Compression and Transfer Molders

INSTALLATION

- Don't overload floor area
- Use sheet metal under machines (to help spot leaks)
- Provide ready access to disconnect means
- Make certain press has hydraulic oil
- Check rotation of motor
- Dry cycle machine for half hour

BEFORE STARTING

- Check mold heater and thermostat holes for proper fit
- Tie rods tight and aligned?
- Bleed condensate from air lines
- Make sure dies are aligned
- Heaters working?
- Lubricate machines daily

AFTER STARTING

- Dry run mold for several cycles
- Adjust hydraulic valves for right press speed
- Steam and pressure reducers working?
- Check for hydraulic fluid leaks
- Make sure flash is being removed from molds
- Keep machine area clean

SHUT DOWN

- Presses should be left in closed position
- Put protective coating of grease over molds
- Clean up press area

SPE JOURNAL

JULY • 1960

Copies of this maintenance system may be obtained from SPE Journal • 65 Prospect St. • Stamford, Conn.
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Trouble Shooting the Hydraulic System

If This is Your Trouble—	Here's What to Look For—	Here's How to Remedy it—
NOISY PUMP:	AIR LEAKING INTO THE SYSTEM	Be sure the oil tank is filled to normal. (with rams retracted), and that the oil intake is below the surface of the oil. Check pump packings, pipe and tubing connections and all other points where air might leak into the system. One way of checking a suspected leak on the intake side is to pour oil over it. If the pump noise stops, you've found your leak.
	AIR BUBBLES IN THE INTAKE OIL	If oil level is low, air bubbles will form in the oil tank. Check oil level daily. Check for clogged or restricted intake line or plugged air vent in the tank. Check strainers in the intake line. Oil viscosity may be too high.
	LOOSE OR WORN PUMP PARTS	Look for worn gaskets and packings; replace if necessary.
	STUCK PUMP VANES, VALVES, PISTONS	Disassemble and clean thoroughly with solvent.
	FILTER OR STRAINER TOO SMALL OR DIRTY	Filters and strainers must be kept clean enough to permit adequate flow of oil. Check filter size.
LEAKAGE AROUND PUMP:	WORN PACKINGS	Replace packing. Trouble may be caused by abrasives in oil. If you suspect this sort of trouble, make a thorough check of points where abrasives may enter system.
OVERHEATING:	OIL VISCOSITY TOO HIGH	Recheck oil recommendation. Unusual temperature conditions may cause oil of **proper viscosity** to thicken. Change oil.
	INTERNAL LEAKAGE TOO HIGH	Check for wear and loose packings. Oil viscosity index may have changed.
	EXCESSIVE DISCHARGE PRESSURE	Trouble may be caused by high setting of relief valve. If so, reset.
	OIL COOLER CLOGGED	If temperatures run high normally, they will go even higher with clogged oil passages. Try blowing it out with compressed air. If this doesn't work, try solvent.
	LOW OIL	Bring to proper level.
PUMP NOT PUMPING:	INTAKE CLOGGED	Check line from tank to pump. Be sure filters and strainers are not clogged.
	LOW OIL LEVEL	Be sure oil is up to recommended level.
LOW PRESSURE IN SYSTEM:	RELIEF VALVE SETTING TOO LOW	Relief valve may have been reset. To check relief setting, block discharge line beyond relief valve and check line pressure with gauge.
	RELIEF VALVE STUCK OPEN	Look for dirt or sludge in valve. Clean if necessary.
	LEAKAGE IN SYSTEM	Check the whole system for escaping oil. Serious leaks in the open are easy to find. But leaks often occur in concealed piping. Install pressure gauge in discharge line near pump and then block out circuit progressively until leak is located.
	BROKEN, WORN OR STUCK PUMP PARTS	Install pressure gage and block system just beyond relief valve. If no appreciable pressure is developed and relief valve is OK, look for mechanical trouble in pump.
	INCORRECT CONTROL VALVE SETTING; OIL SHORT CIRCUITED TO TANK	If open center directional control valves are unintentionally set at neutral, oil will be returned to tank. No pressure will be developed. Also; scored control valve pistons and cylinders can cause this trouble.
ERRATIC ACTION:	VALVES, PISTONS, ETC. STICKING OR BINDING	First check suspected part for mechanical deficiencies such as misalignment of a shaft, worn bearings, etc. Then, look for signs of dirt, oil sludge, varnishes and lacquers caused by oil deterioration.

With central accumulator power plant operation, particular attention should be given to checking for leaks in lines and valves. When power is turned on, steam reducers and traps must be checked to see that they are working. The same is true for pressure reducers. If pressure begins to rise, there is a leak and the machine should be shut down and the regulator repaired.

With mold installed and check-list completed (see check-list, page 684), dry run the mold for several cycles. **Caution**: Check hydraulic pressure. Also, it is a good idea to use carnauba wax on the mold during the initial break-in period. Using the proper maintenance and preventive maintenance procedures outlined above, the press is ready to put into production.

Preventive Maintenance During Operation

Once the machine is in operation, the mold should be inspected to make certain that all flash is being removed. The machine area should also be kept clean. Some molders make a practice of cleaning up twice per shift, others once a shift, and still others clean up on Saturdays only. The point is, whether it's once a day or once a week, the machine area should be cleaned. Depending upon the geometry of the molded piece, adjust the speed of ejection so that the piece doesn't fall off the ejector pins. If this happens, the piece might fall into one of the cavities, and the mold might be subsequently damaged when the press is closed. A final tip: Make certain all rags and tools are clear of the press area during operation.

Hydraulic Maintenance

Oil level in machines should be checked daily. With accumulator power plant systems, it is suggested that the specific gravity of the hydraulic fluid be checked daily. Imbalance in water-additive systems might change operating conditions on the production lines and cause damage to cylinders and transfer plungers. For automatic machines, care should be used in selecting the hydraulic oil. Only well refined mineral oils and preferably grades of the type especially made for hydraulic service should be used. As with injection machines, it is important to change oil regularly, every six months or every year, or as recommended by the machine manufacturer. With new machines, it is recommended that the oil be changed after one month's operation.

Over long periods of time, it may be necessary to replace packings in hydraulic cylinders, as evidenced by leakage around those cylinders. To continue operation with faulty packing is to invite corrosion and subsequent pitting of the cylinders. When replacing packings, do not crush them by pulling down too much on the glands. Tighten the nuts evenly, distributing the load over the entire gland.

Machines should be lubricated daily. Where pressure gun fittings are provided, use a good quality lime base grease with a low melting point. Two or three shots for every 8 hour shift should be sufficient.

Electrical Maintenance

All parts, such as motors, relays, microswitches, cannon plugs, timers, and thermocouples should be kept as clean as possible. Cycle controllers on semi-automatic equipment should be blown out with compressed air at least once a week. Compressed air lines leading to cycle controllers should be bled daily to get rid of oil and water condensate, although in winter months this may not be necessary.

Bearings and lubricants in electric motors should be checked every six months. If the grease is too fluid or dirty, clean out the chamber and refill. Periodically check motor temperatures with a thermometer. The temperature rise above the surrounding air at which the motor will not exceed its rated load is, in most cases, stamped on the motor nameplate. If thermometer readings show the temperature to be above this reading, check the ambient temperature. If too high, provide a means for ventilating the room more properly or install fans to bring room temperature down. A high motor temperature caused by other than overload or motor internal failure will not trip the overload relays in the motor starter. (Totally enclosed motors are recommended).

Thermocouples should be examined regularly for signs of deterioration. This should be a *regular routine* even though the control instruments are equipped with a thermocouple break protection device. Contacts on starters and relays should be examined for signs of pitting or burning. However, they generally have to be replaced only after the silver alloy has been worn away. Once a month inspection should be made of all screws and connecting wires for loose connections caused by vibration.

Limit switch covers should be removed and the switch operated by hand to determine if contacts open and close properly. Treat limit switch contacts the same as starter and relay contacts. Check occasionally for mechanical wear. Timers do not require special attention. The motors are sealed units and must be replaced if failure occurs. It is faster and easier to replace the entire timer than to have repairs made. Inspect solenoids regularly. Check for loose connections, bolts on push rods and improperly sealed magnetic circuits. If the coil feels too hot, check temperature with a thermometer. Temperature limits are the same as for motors.

Maintenance of Auxiliary Equipment

Lubrication is the most important part of maintenance of compression molding auxiliary equipment. Deflashing or mechanical deburring equipment requires lubrication of motors (blowers and baskets) and main bearings about once a week. Visual checks should also be given to belts to spot wearing and cracking.

RF preheat equipment should be cleaned out with compressed air (or using vacuum) once a week to minimize down time. Access panels should be removed weekly and the unit checked for loose connections as well as to make certain rectifiers are working.

Preformers should be lubricated weekly and the oil changed once a year. As with compression and transfer presses, the machine should be checked visually to make certain that tie rods are aligned and dies operating properly.

A sound maintenance program is as much an investment in your plant's operation as new machines. And like a direct capital investment, it has an important bearing upon continuous high output and lowest production costs.

Acknowledgment

Special thanks to the following companies which supplied information for this article:

Farrel-Birmingham Co., Inc., Rochester, N. Y.

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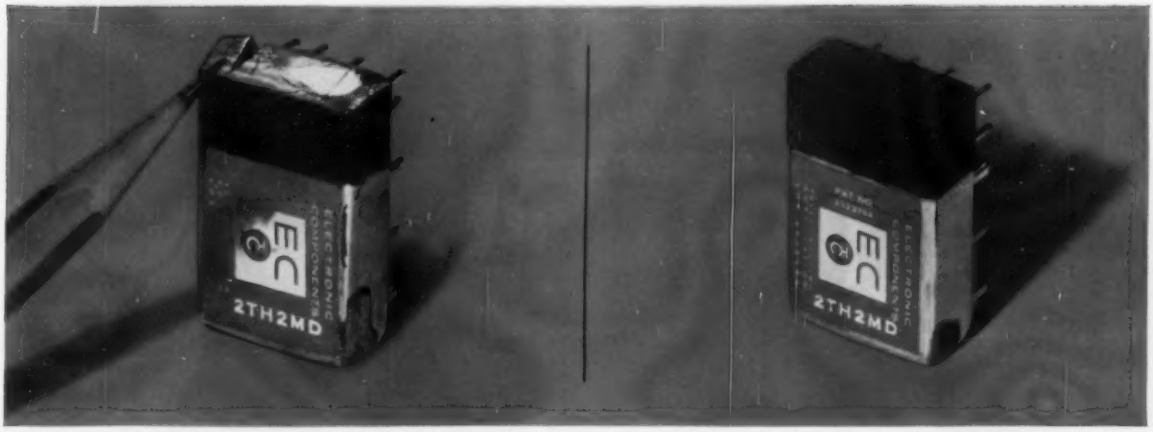
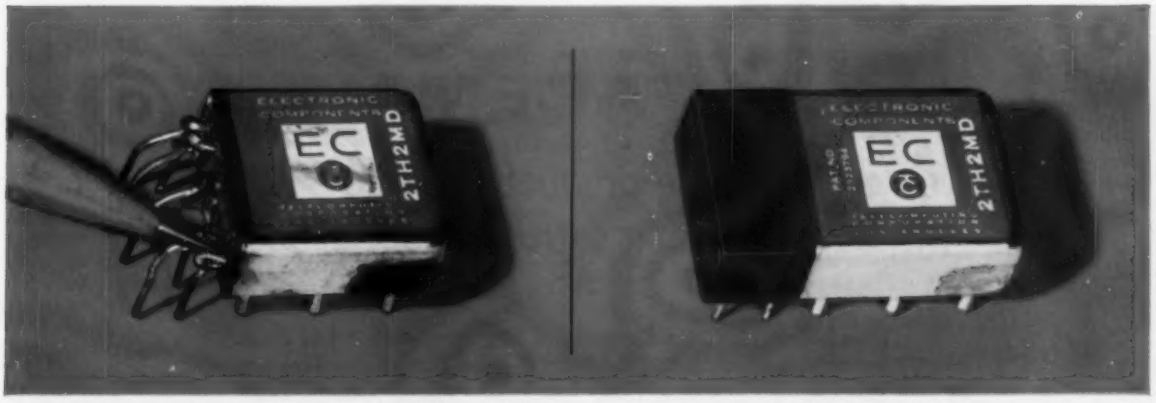
Plastic Products, Inc., South Norwalk, Conn.

DOW | THERMOSETTING RESINS



Under 180°C. heat, the ordinary epoxy resin cracked . . . but the epoxy novolac potting was unharmed!



In an epoxy stripper, the epoxy resin potting dissolved . . . but the epoxy novolac showed no significant change after two weeks' immersion!

DOW EPOXY NOVOLAC UNHARMED

by brutal heat and chemical torture tests!

Tests conducted by an electronics component manufacturer prove it! Compared on the basis of their ability to withstand extreme heat and powerful chemical attack, these two miniature relays demonstrated the amazing difference between a regular high-quality epoxy resin, and Dow epoxy novolac resin (D.E.N. 438).

The test to determine the effects of prolonged intense heat on these two terminal pottings took place in a 180°C. oven. After five hours, the ordinary epoxy resin potting compound cracked. But after 100 hours of continuous 180°C. heat, the Dow epoxy novolac was unharmed!

A chemical resistance test compared the ability of each potting compound to withstand the action of high-powered stripping solvents similar to solvents used in cleaning electronics equipment. The ordinary epoxy resin formulation was completely dissolved after only 48 hours in the stripper. But the Dow epoxy novolac potting showed no significant change, even after two weeks' immersion!

These results prove once again that in potting, molding, encapsulating and laminating, or in any application where performance is critical, Dow epoxy novolac resins can provide the extra measure of physical and chemical stability necessary for success.

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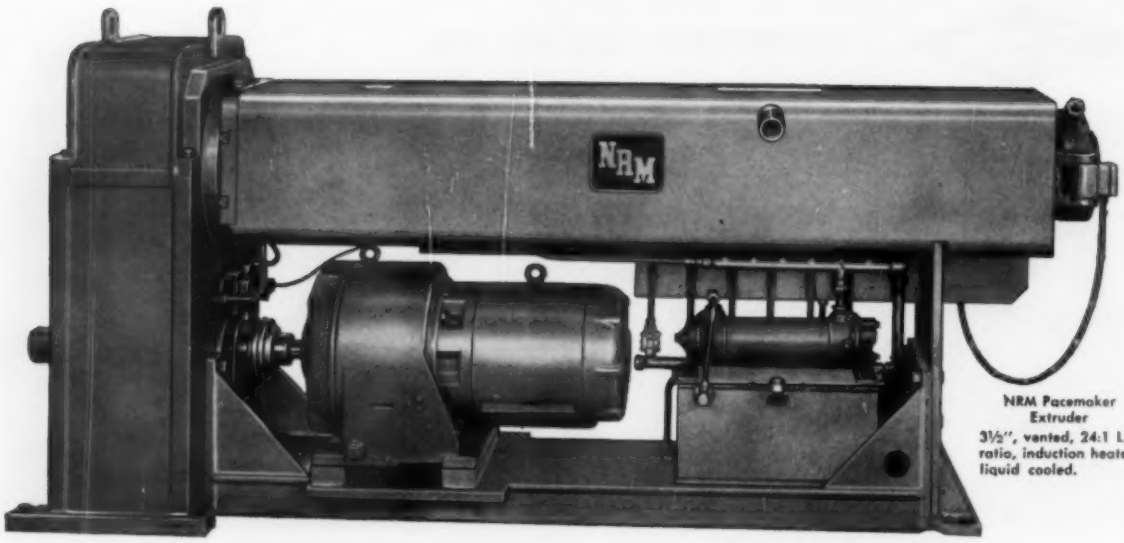

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The Dow Chemical Company

SPEAKING OF EXTRUSION

Extrusion: Described by Experimentally Determined Equations

Normally single screw extruders can be divided into two main classes; plasticizing extruders and melt extruders. The melt extruder is a simpler case to treat. The melt extruder has been carefully treated by Carley, et. al. (1) On the other hand the plasticizing extruder is used most extensively, particularly for polymer fabrication, and probably offers the greatest challenge to any sort of theoretical interpretation of experimental results.

Existing Theories

For convenience a brief review* of the equations previously derived is presented. Rowell and Finlayson (2) derived an expression for screw extruders which was later expanded and treated more thoroughly by a number of investigators (1) to yield the following general equation:

$$Q_o = Q_D - Q_e - Q_B. \qquad (1)$$

Q_o is the output of the extruder, Q_D is the drag flow or that flow which results from the forwarding action of the screw, Q_e is the leakage flow or that flow which results from polymer flowing between the flight of the screw and the barrel, and Q_B is the back flow or that flow which results from the hydraulic system (a pressure drop occurs and the molten polymer is a highly viscous fluid). Detailed inspection and theoretical analysis of equation 1 produced an equation showing how the output varied with pressure, screw speed, and viscosity. This is represented by equation 2. N is the screw speed, h^* the effective depth of the flight, P is the pressure developed by

$$Q_o = \alpha_o h^* N - \frac{\beta_o h^{*3} P}{\mu} - \frac{\gamma_o h^{*2} P}{\mu} \qquad (2)$$

the screw and to be more precise it is the pressure drop across the rate controlling section of the screw, and μ is the viscosity of the polymer extrudate. Let it suffice to say that α_o, β_o, and γ_o are geometric constants related to the screw geometry. (For details see reference 1.)

This article is a summary of some of the experimental work which has been designed to determine methods for describing extruder design and its relation to the flow properties of polymers. In particular the work reported attempts to relate equations of the type previously obtained to plasticizing extruders.

How the Results Were Obtained

This work was carried out with a 2.5" electrically heated extruder with 4 independently controlled heating

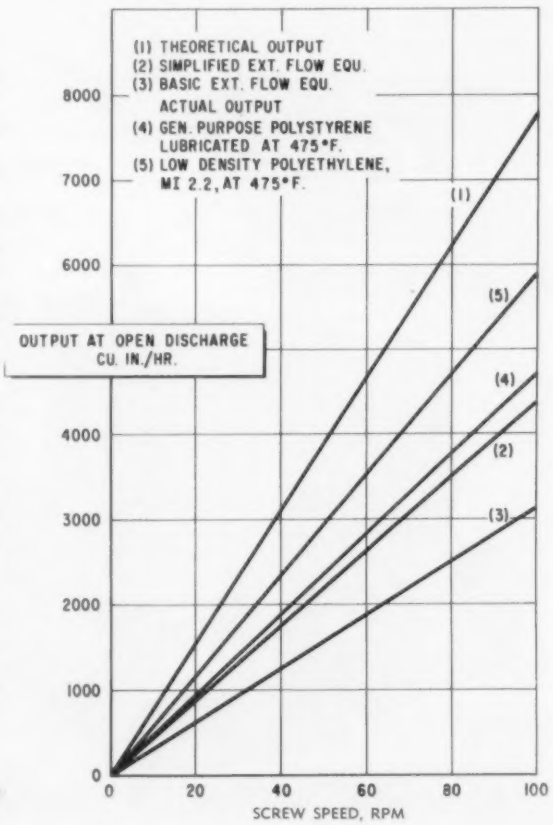
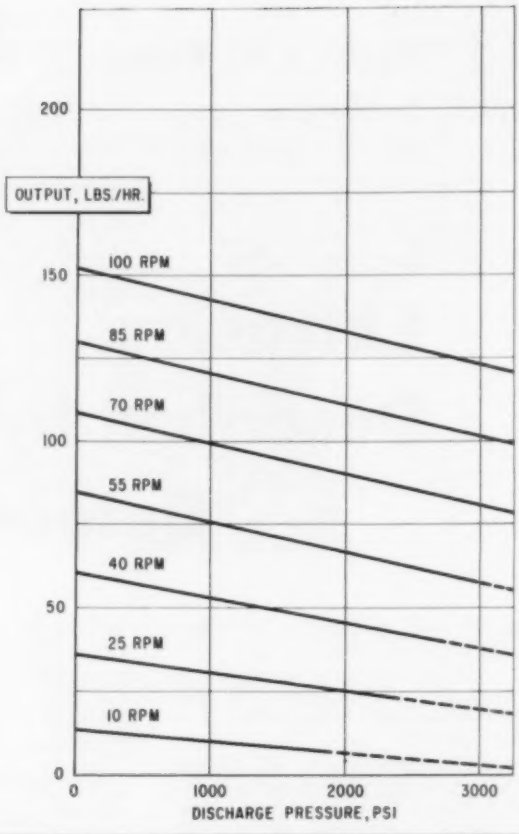


Figure 1. Graphs show correlation obtained when experimental data for polystyrene and polyethylene is compared to calculated values.

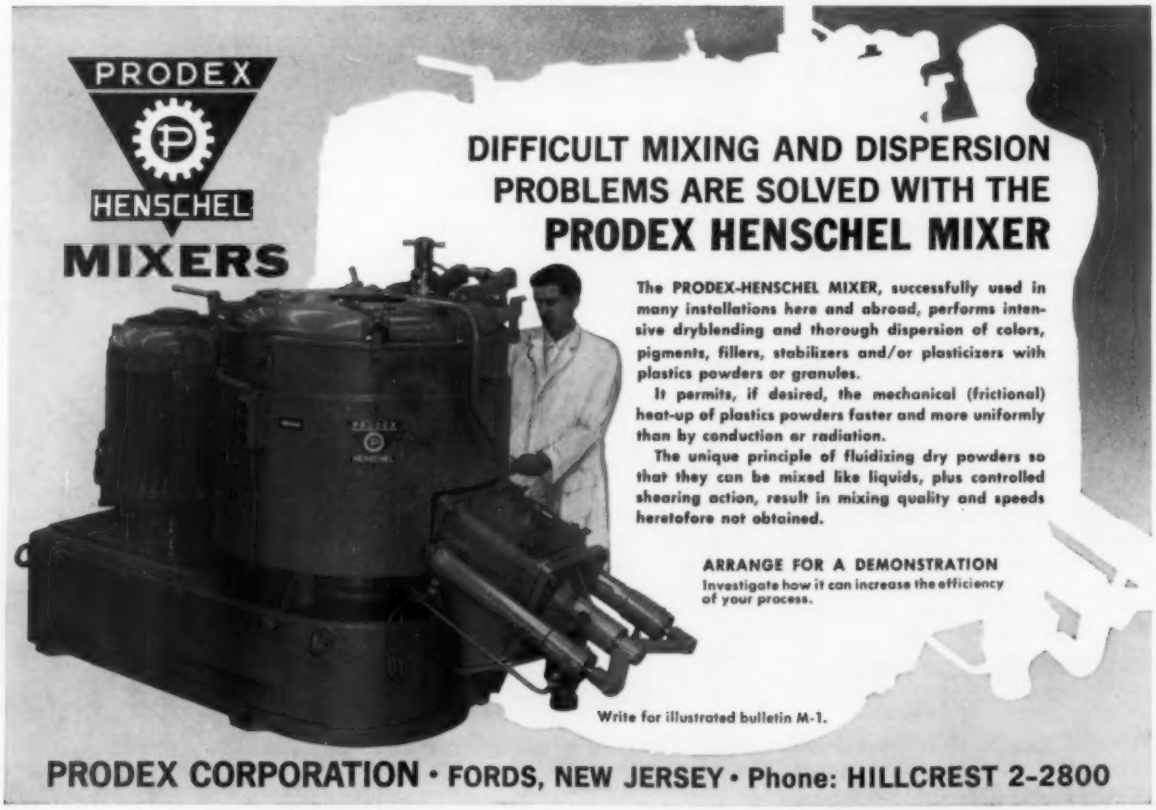
* An excellent bibliography of references is given in reference 5.

Figure 2. Discharge pressure vs. output rate for low density polyethylene, MI 2.2.



zones. The screw was a modified single flighted polyethylene screw which had a feed section of 11 flights, a 3.33 compression section of 9 flights, and a forwarding or melt section of 6½ flights. The over-all L/D ratio was 20:1 and the screw pitch varied from 1.75″ to 2″. The output data was obtained by conducting a series of extrusion tests in which the screw speed, back-pressure, and heater temperatures were varied and the resulting output was quantitatively measured over a fixed time interval. High impact polystyrene (lubricated and unlubricated), general purpose polystyrene, high and low density polyethylene were all tested.

Figure 1 shows the agreement obtained when the experimental data for polystyrene and polyethylene is compared to various calculated values. All experiments were carried out at open discharge where the backflow would be small or zero. Line (1) represents the theoretical output if the volumetric efficiency was 1, line (2) was calculated from the simplified flow equation (2), and line (3) was obtained from the basic flow equation (2). Curves (4) and (5) are the experimental results obtained on lubricated general purpose polystyrene and on low density polyethylene respectively. The actual experimental output for the polyethylene was 35% higher than predicted from the simplified equation, and 10% higher than predicted when polystyrene was used. The agreement was poorer when the basic equation was used. Mathematical attempts to force the experimental and theoretical results into agreement were not very successful, and attempts were then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EXAMPLE 1.

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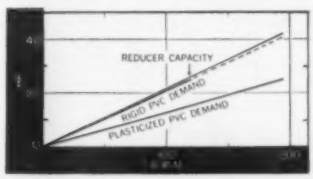
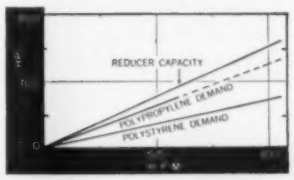


EXAMPLE 2.

The new 4½" PRODEX **HT** EXTRUDER, equipped with a 75 HP Dynamatic drive and gearing for 90 rpm max. screw speed, turns out 650 lbs/hr of high impact polystyrene without predrying. In order to run polypropylene M.I. 0.2, change gears for 65 rpm max. speed are used to deliver about 500 lbs/hr of this material. Without change gears, this machine would need a 125 HP drive, which would result in a substantial horsepower waste.



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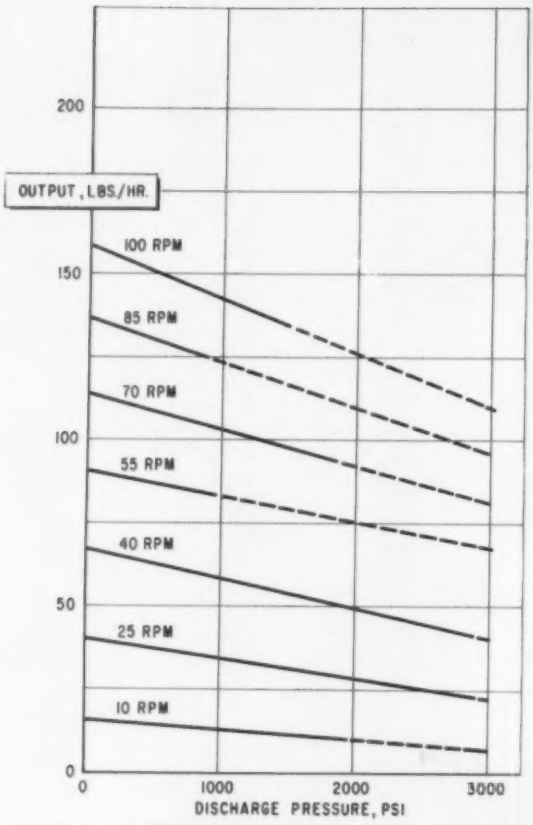

Figure 3. Die pressure vs. output rate for high impact polystyrene.

Table 1. Coefficients of Equations Obtained For Polystyrenes

Polymer	Temp.	a	b	c x 10^4	d x 10^5
High Impact*	475°F.	0.25	1.78	−1.03	−3.17
High Impact*	400	0.23	1.75	−1.23	−0.91
High Impact*	400	2.19	1.69	−1.22	−0.18
High Impact	475	1.22	1.60	−1.31	−2.78
General purpose	473	2.80	1.58	−1.36	−3.48
General purpose	375	0.00	1.59	−1.55	−0.78
Heat Resistant	475	2.48	1.57	−1.08	−2.10

* Not lubricated. All others lubricated.

Table 2. Coefficients of Equations Obtained For Polyethylenes

Polymer	Melt Index	Temp.	a	b	c x 10^4	d x 10^5
High density	2.1	475°F.	0.103	1.36	−0.427	−4.82
Low density	2.1	475	0.429	1.50	−0.463	−3.44
Low density	2.1	400	1.947	1.52	−0.615	−1.36
Low density	2.1	300	1.421	1.50	−0.527	−0.96
Low density	2.2	475	0.801	1.52	−0.660	−2.54
Low density	2.2	300	1.579	1.50	−0.802	+0.21
Low density	2.2	475	0.628	1.51	−0.520	−4.47

made to find a new equation to represent the observations. (It is worth noting that the experimental results followed a straight line so closely that only a few experimental points are illustrated, although a great many more points were obtained.)

Further treatment of the data indicated that the output was a linear function of the back pressure at fixed screw speed. *Figure 2* illustrates curves obtained for low density polyethylene, melt index of 2.2, and *Figure 3* illustrates the data obtained for high impact polystyrene. Similar curves have previously been published elsewhere (3) (4). Inspection of these curves readily suggests that the output varies with the screw speed at some fixed pressure; and from curves of the type shown in *Figure 2 and 3*, we obtained *Figure 4*. All the data obtained was taken at a fixed temperature setting on the extruder, thus the polymer temperature was constant to only about ±10°F. However, experimental checks on the temperature showed that the results were not appreciably influenced by this temperature variation.

Each of the straight lines shown in *Figure 4* can be represented by an equation of the type $Q_o = mN + C$ where m is the slope and is some function of the pressure. Solution of a number of these equations led to a single equation of the type:

$$Q_o = bN + cPN + dP. \quad (3)$$

Q_o, N, and P are as previously defined and b, c, and d are constants. After this initial effort the data was fed into a computer which arrived at an equation of similar form but with a small additional numerical constant, a. This equation is:

$$Q_o = a + bN + cPN + dP. \quad (4)$$

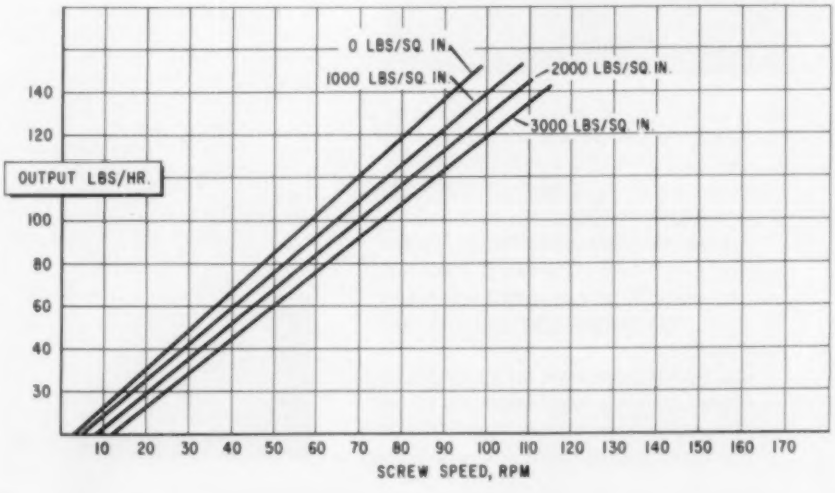

Figure 4. Output vs. screw speed and pressure.

Tests indicated that this equation represented the data with a correlation factor of over 0.99.

A term by term comparison of equations 2 and 4 shows that there is considerable similarity between the two. Both contain terms in which the output varies only as a linear function of the pressure and terms in which the output varies as a linear function of screw speed. However, equation 4 also contains a small numerical constant, and it contains a cross product term in N and P which was not present in the theoretical derivation.

Analysis of the Experimental Equations

In the preceding sections no attempt has been made to assign significance to any of the constants in equation 4. Let us now assume that bN corresponds to the "drag flow" term of equation 2, recognizing that there may not be a strict correspondence between $\alpha_s h^*$ and b. Since our experimental equipment had minimial clearances between the screw and barrel it is doubtful that there are significant amounts of leakage occurring. Therefore, $Q_c = 0$ and will be neglected. It then remains to reconcile Q_b with cPN and the dP terms of equation 4. Since both terms have negative coefficients, and increase in pressure results in a decrease in output as would be expected, but one might not expect that an increase in screw speed also would result in a decrease in outp t. A more careful examination of the cPN term is required. By assumption, we write:

$$Q_b \sim cPN + dP \qquad (5)$$

Examination of equation 5 indicates that when $d >> c$ and N is small the equation reduces to the same form as Q_b found in equation 2. The experimental data obtained (*see Tables I and II*) indicates that for the 2.5" extruder d/c is normally between 10 and 30. At all screw speeds above the very slowest the cPN term cannot be neglected to adequately interpret the data obtained with this extrusion equipment. In addition, we do know that under certain conditions the output would be expected to become a lesser function of screw speed and even drop if N becomes sufficiently large. (6) It is our current opinion that although N appears as the independent variable it is indeed the heat generated by shear which raises the polymer temperature. This in turn produces the effect. (6) Based upon these and other observations we write from equation 5:

$$Q_b \sim P\phi\,(d_1 + c_1 f(T)) \qquad (6)$$

where $d_1\phi = d$, $c_1\phi = c$, and ϕ is the fluidity of the molten polymer. Substitution of equation 6 into equation 4 yields the general equation:

$$Q_o = a + bN + P\phi(d_1 + c_1 f(T)) \qquad (7)$$

where d_1 and c_1 are geometric constants. This equation reduces to $Q_o = a + bN + P\phi d_1$ when $|d_1| >> |c_1 f(T)|$, which is analagous to equation 2 except for the small constant a.

Table 1 shows the coefficients of the various polystyrenes tested.

The constant a is seen to be rather small and contributes only slightly to the value calculated for output. Ideally this constant should disappear or be negative since at zero screw speed the output should be zero. The negative value could appear if starting inertia exists in the polymer flow. The small positive constant probably results from difficulty in making totally accurate pressure measurements.

In examining the coefficient b we note that it remains relatively constant for the same material regardless of the temperature of extrusion. The effect of lubrication is apparent when a comparison is made between the values obtained for high impact polystyrene—lubricated and unlubricated. The coefficient decreases with lubrication as would be expected.

The coefficient d also behaves as expected. Since $d = d_1\phi$ and ϕ decreases with decreasing temperature, we would also expect $\bar{d}$ to decrease. However, the coefficient c is a different situation since it is to be multiplied by a function of temperature which is largely unknown. We do observe that $\bar{c}$ generally increases slightly with a decrease in temperature; a fact which should be anticipated since the effects of shear would be more pronounced with the higher viscosity materials. The manifestation would undoubtedly be higher localized temperatures and more fluidity than might ordinarily be expected.

Table 2 illustrates data obtained when various polyethylenes were used in the extruder. The same conclusions apply here as was previously stated for the polystyrenes. There is one abnormality which shows in this table and that concerns the positive term encountered in the d term of the equation for low density, 2.2 melt index, polyethylene at 300°F. One suggestion has been made to explain this apparent anomaly—that at temperatures sufficiently low the feed and/or the compression section are contributing to the forwarding of the molten polymer through the melt section of the extruder.

Conclusions:

1. A number of experiments have been carried out and the results fitted to a single equation of the type $Q_o = a + bN + cPN + dP$.
2. This equation bears a strong resemblance to previously derived equations, but it contains an additional term in P and N. Under certain suggested conditions it can be reduced to produce an equation analogous to the derived ones.
3. The coefficient b of the experimental equation decreases when the feed stock is lubricated. The coefficient appears to be independent of barrel temperature.
4. The coefficient d is a function of the polymer fluidity and certain geometric constants. "d" decreases with increasing temperature.
5. Similar to (4) the coefficient c is also a function of the fluidity and geometric constants. The product $cN = c\,f(T)$ has been associated with localized heating produced by shear in the extruder.
6. The preceding five conclusions are to a large extent qualitative in nature and have been deduced from the experimental evidence presented and with a certain amount of intuition.

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This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

edited by
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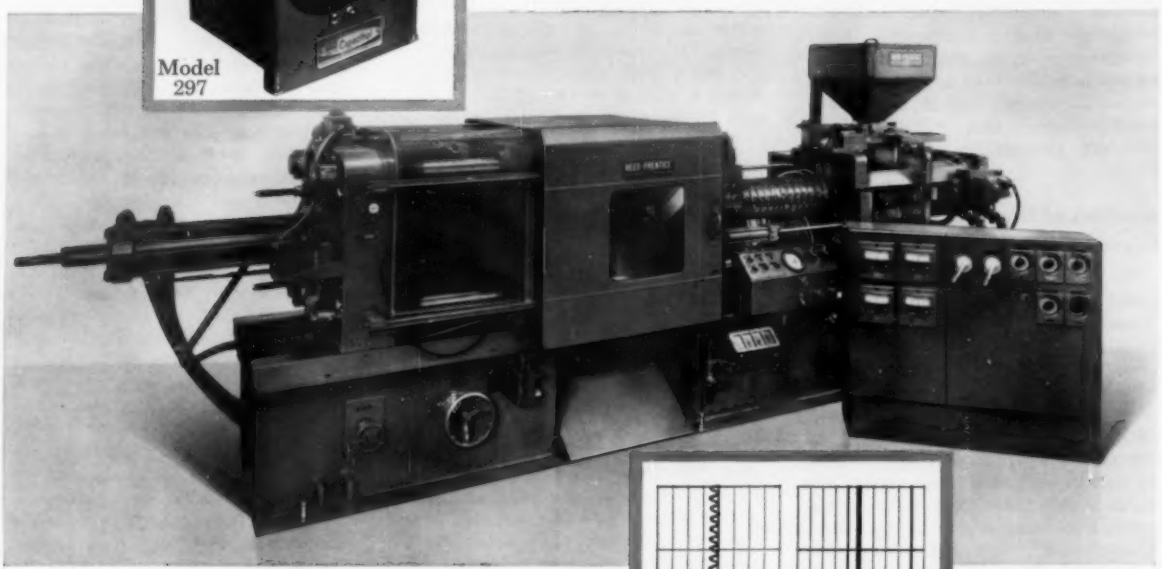
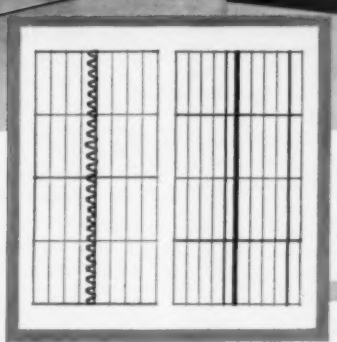
another Wheelco specification story...





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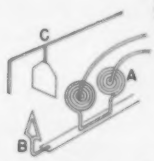

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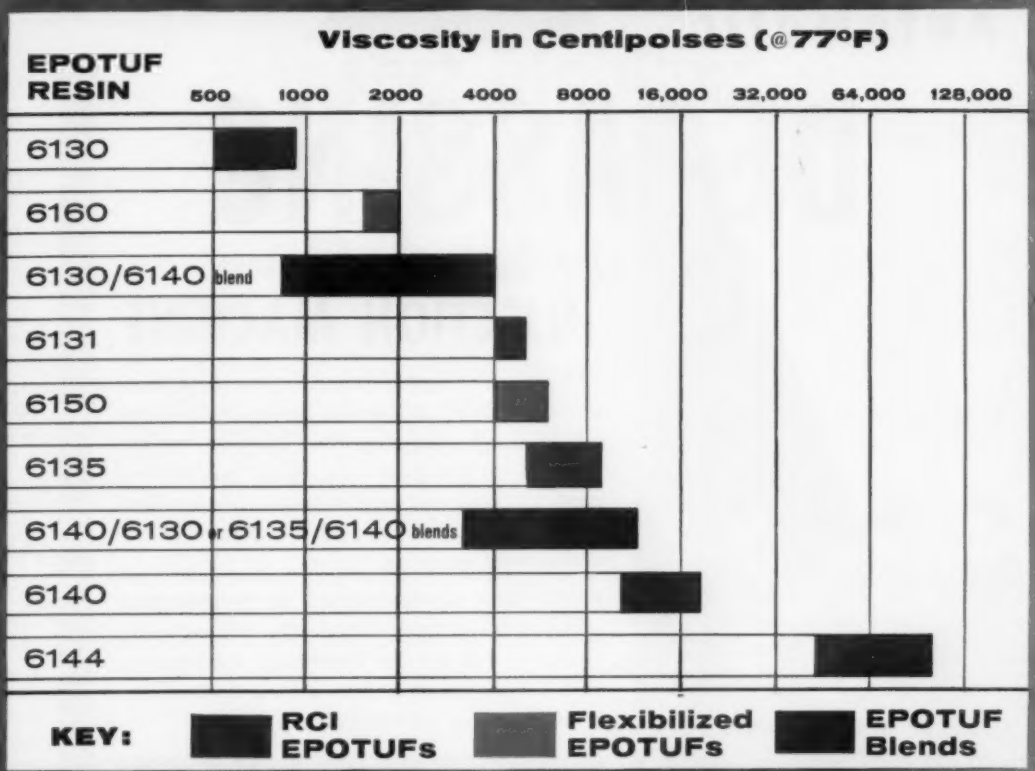

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MOLDING CYCLES

Insert Molding With High Density Polyethylene

Lessons for the insert molder:

Higher melt index materials can be molded with less strain
Don't go below .125" in wall thickness
Eliminate or reduce the thickness of any knurling on inserts
Aluminum and brass inserts are preferable to steel

Insert molding is the integral incorporation of metal pieces in the molded part during the actual machine production cycle of the injection molding process. These inserts are, for the most part, functional rather than decorative. The most common are internally threaded inserts molded into bosses on the back of a panel so that the panel may be assembled to another part by means of threaded metal bolts or screws. Another category of application is encountered where plastic must be molded around a supporting and reinforcing structural piece such as steering wheels, handles and miscellaneous industrial parts.

This paper describes insert molding with high density ethylene homopolymers of 0.96 density varying in melt index from 0.7 to 2.5, and copolymers of 0.95 density varying in melt index from 0.8 to 2.5. These ethylene copolymers are specially designed linear polyolefins manufactured by the catalytic copolymerization of ethylene and butene-1 at low pressures, and are characterized by controlled positioning of short chain branches along the main polymer chain. Ethylene homopolymers, on the other hand, are characterized by a linear type structure with very little branching which is responsible for their higher density.

Past experience with high density polyethylene has revealed the susceptibility of this material to cracking under certain conditions when inserts are used.

This phenomenon is essentially one of stress cracking caused by molding strains due to high mold shrinkage of this material. In the work covered by this paper, the phenomenon was studied by testing molded parts under two conditions known to facilitate cracking; namely, (1) thermal stress cracking, described as cracking after prolonged exposure to high temperature, and (2) environmental stress cracking, the degradation of material caused by surface active chemicals.

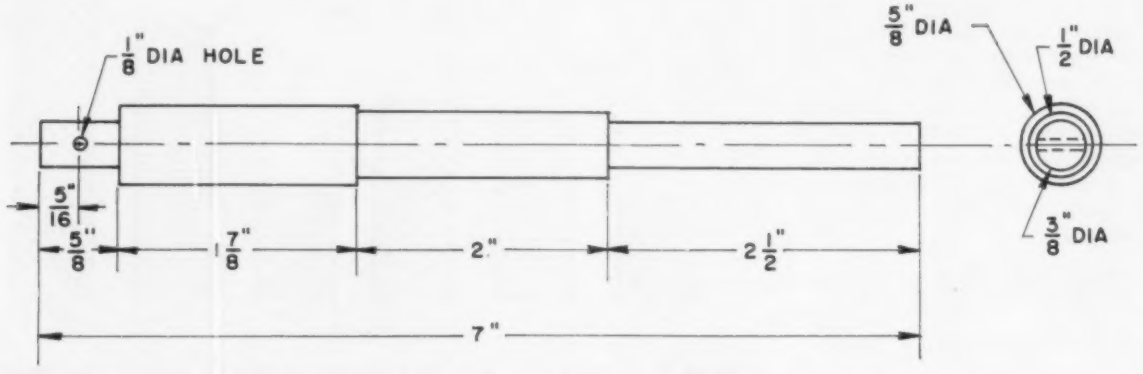


Figure 1. Stepped insert design chosen to give three different wall thicknesses.

Preparation of Samples

The suitability of high density polyethylenes for insert molding might conceivably depend upon the selection of the type of metal from which the inserts are fabricated. Three different common metals; namely brass, aluminum and cold rolled steel were investigated.

The insert design, whose configuration is shown in *Figure 1*, was chosen to give three different plastic wall thicknesses namely 0.050", 0.115" and 0.163", so that the effect of wall thickness on the cracking phenomena could be studied.

Since several different types of surfaces are used on inserts in actual practice, heavy diamond knurls were machined into some of the inserts. This provided both smooth and knurled inserts for evaluation. The part was gated in the heavy section using two rectangular gates (3/16" wide x ¼" deep x ¼" long) located 180 degrees from one another. The gates were fed from a ring gate located adjacent to the runner.

Each of the four high density polyethylene materials described earlier were insert molded using both knurled and smooth inserts prepared from aluminum, brass, and cold rolled steel.

Specimens molded from each of these polyethylenes and the various insert types were subjected to two stress cracking tests. These tests consisted of subjecting specimens to 240°F., in an air circulating oven and to 180°F. in Igepal CO-630. For the purpose of evaluation any type of crack or fissure which appeared on the molded parts was considered a failure. Tests were continued until 100% failures were experienced or until 1000 hours exposure were reached at which time tests were terminated.

All materials investigated in this study were molded under the same conditions to provide uniform shrinkages among inserts, although, for best results, materials of low melt indices (0.7 and 0.8) are normally molded at temperatures of 50°F. to 100°F. higher than those used in this study. Parts were molded on a 2-ounce Stokes machine (Model 701) using the following conditions.

Cylinder Temperature,	
Front	400°F.
Rear	400°F.
Material Temperature	390°F.
Die Temperature	115°F.
Cycle, Injection	12 sec.
Clamp	20 sec.
Overall	45 sec.
Injection Pressure	900 psig.

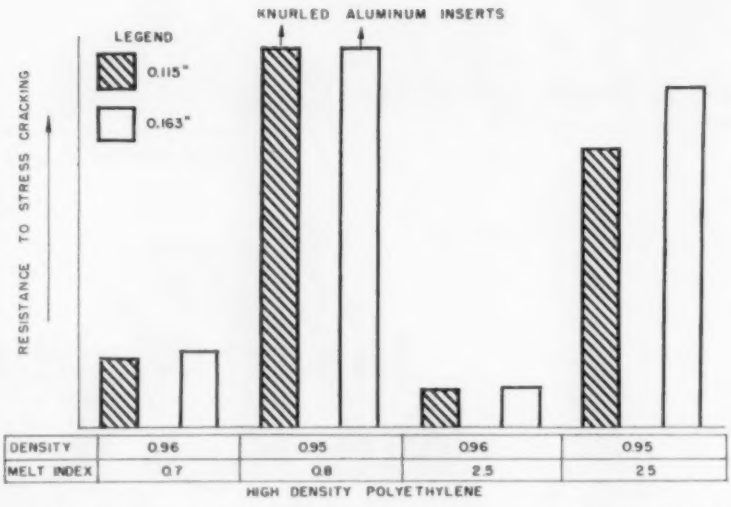


Figure 2. Effect of wall thickness on stress cracking resistance of high density polyethylene-Igepal at 180°F.

Evaluation of Polyethylenes

Relative stress cracking resistance of the four polyethylene materials were evaluated using knurled aluminum inserts and tested at 240°F.; *Figure 2* gives the test results when these were tested in Igepal at 180°F. Data are presented for two wall thicknesses; namely, 0.115" and 0.163".

Results obtained from the 240°F. aging test show that the 0.95 density ethylene copolymer offers superior stress cracking resistance to the 0.96 density homopolymer and that the 2.5 melt index is better than the 0.8 melt index copolymer. These effects may be attributed to the inherent lower crystallinity of the lower density material and to the fact that higher melt index materials can be molded with less strains.

Trends indicated from results obtained in the Igepal at 180°F. (see *Figure 2*) test illustrate once again the higher stress cracking resistance properties of the 0.95 density copolymer polyethylenes as compared to the 0.96 density homopolymer polyethylenes.

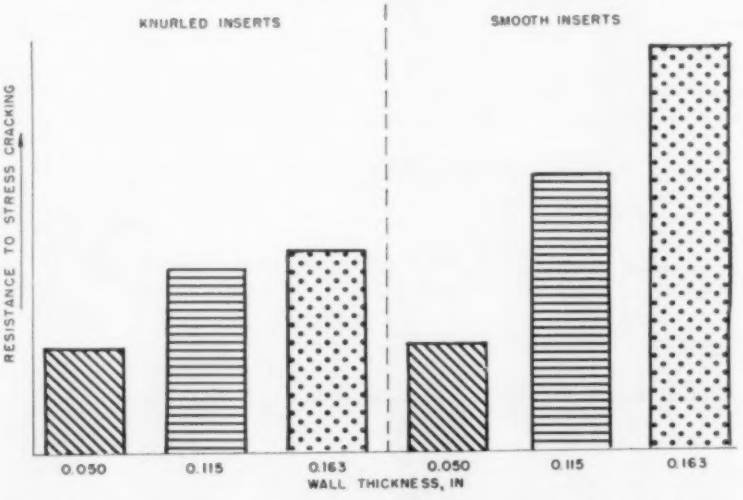


Figure 3. Relationship of stress cracking resistance to wall thickness-Igepal at 180°F.

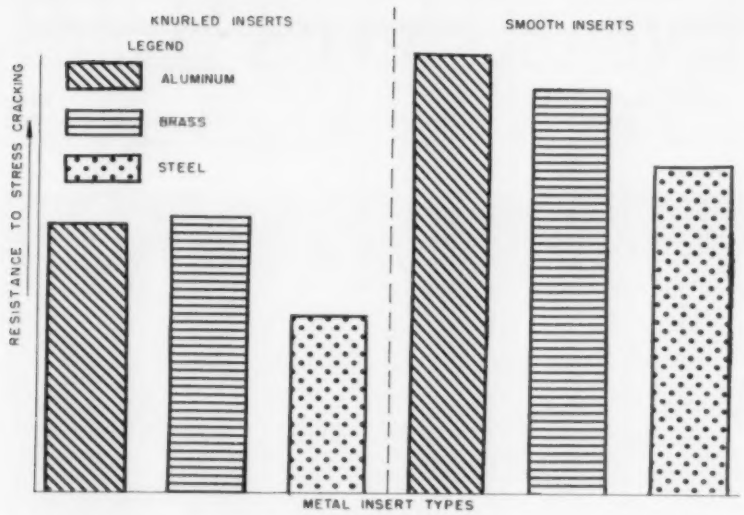


Figure 4. Relationship of stress cracking resistance to metals—Igepal at 180°F.

In this test, however, the data indicate that the lower melt index (0.7-0.8) materials show better environmental stress cracking resistance than the higher melt index (2.5) materials. This effect illustrates the inverse relationship between environmental stress cracking resistance and melt index.

Effect of Wall Thickness

Results obtained from tests conducted in Igepal at 180°F. are shown in *Figure 3*. These results illustrate the relationship of polyethylene stress cracking resistance to varying wall thicknesses of 0.050", 0.115" and 0.163". Averages were used to establish the overall trends.

In general, stress cracking resistance of high density polyethylene improves directly with increasing wall thickness of the plastic around the metal inserts. In both tests (that is, *Figure 3* and at 240°F.–graphs not shown) stress cracking resistance obtained with smooth inserts was significantly greater than that obtained with knurled inserts of comparable wall thickness as shown in specimens with 0.115" and 0.163" wall thicknesses. In high density polyethylene insert molding applications, the use of very thin wall thicknesses is to be avoided and it is recommended that wall thicknesses of at least 0.125" be used.

Effect of Metals

Figure 4 shows the effects various metals have on stress cracking resistance of high density polyethylenes. These data represent average stress cracking values obtained on the various polyethylenes as related to particular metal and surface types of inserts.

Aluminum and brass appear to be more suitable for insert applications than steel based on results obtained in Igepal at 180°F. However, in the 240°F. test the brass did not appear to be as good as either aluminum or steel, possibly because of a degradative effect of copper on polyethylene at this extreme temperature. The latter effect needs to be confirmed by additional work.

The superior performance characteristics of the smooth inserts over the knurled inserts once again are illustrated by these data. This effect may be attributed to variations in wall thicknesses that reflect the dimensions of the knurling and to highly strained areas that result from the plastic flow patterns around the knurling.

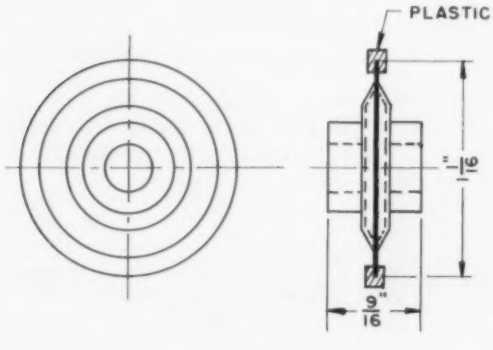
Case Histories on Molding

1. The part being molded in this case was a stainless steel insert of the general configuration shown in *Figure 5*. The material was high density polyethylene. This application called for molding a section roughly 0.160 inch in thickness around the periphery of the insert.

Parts were molded in a four-cavity mold using single edge gates, a 2-ounce Van Dorn machine, and high density ethylene homopolymers of 0.96 density-0.7 melt index and 0.95 density copolymers of 0.8 melt index. Molding conditions used in this investigation are shown below:

Cylinder Temperature,	
Front	440°F.
Rear	440°F.
Material Temperature	440°F.
Die Temperature	100°F.
Cycle, Injection	10 sec.
Clamp	35 sec.
Overall	55 sec.
Injection Pressure	1000 psig.

For the purpose of evaluating the stress cracking properties of these high density polyethylenes and their rela-



◄ **Figure 5.** Stainless steel insert—see Case History 1.

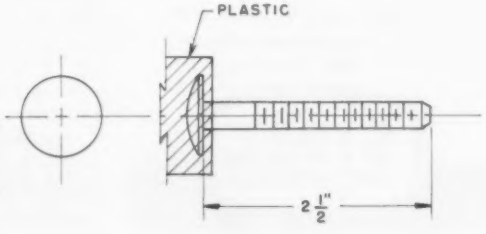


Figure 6. ► Brass bolt insert—see Case History 2.

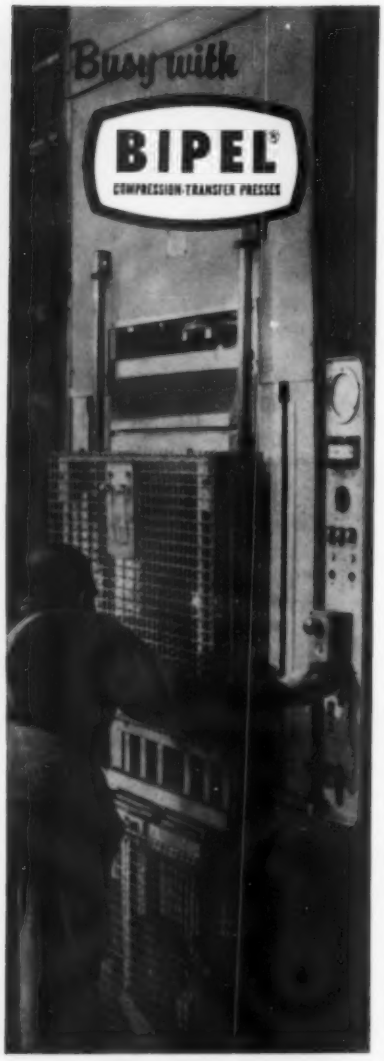


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Table 1. Stress Cracking Resistance of High Density Polyethylenes

Polyethylene Density	Polyethylene Melt Index	Test	Number Tested	Number Failed, %	Days To Failure
0.96	0.7	240°F.	8	100	<5
0.95	0.8	240°F.	8	100	12-15
0.96	0.7	In Igepal at 180°F.	16	100	<5
0.95	0.8	In Igepal at 180°F.	16	30	12-51
0.96	0.7	180°F.	16	100	3-20
0.95	0.8	180°F.	16	0	>52

tive effectiveness in this application, molded inserts were subjected to three tests consisting of heating at 180°F., at 240°F., and in Igepal CO-630 at 180°F. Results from these tests which were terminated after fifty-one days duration are shown in *Table 1*.

These tests show that the stress cracking resistance of the 0.95 density-0.8 melt index is greatly superior to the 0.96 density-0.7 melt index polyethylene. These data also point out that the relative severity of these tests in decreasing order are 240°F., in Igepal at 180°F. and 180°F.

2. Brass inserts of the general configuration shown in *Figure 6* were being molded using high density polyethylene. This part, in particular, was molded to provide a relatively heavy wall section of roughly 0.180 inch around the head of the bolt.

Parts were molded in a multi-cavity mold with single edge gates in a 8-ounce Reed-Prentice machine using high density ethylene copolymers of 0.95 density in melt indices of 0.8 and 2.5 Molding conditions used in this investigation are as follows:

Cylinder Temperature,	
Front	430°F.
Rear	430°F.
Material Temperature	420°F.
Die Temperature	140°F.
Cycle, Injection	19 sec.
Clamp	32 sec.
Overall	75 sec.
Injection Pressure	1000 psig.

The particular nature of this end use application required these inserts to be subjected to a continuous load. Consequently special tests were developed to evaluate these inserts under loads of zero, six, and ten foot pounds torque at 180°F.

Results from these tests indicated that after six weeks exposure at this condition all specimens under various applied loads which were molded in high density ethylene copolymers from both melt indices were found to be satisfactory. In this test, no failures were experienced with any of the inserts.

Conclusion

From this work, it may be concluded that a 0.95 density material prepared by the copolymerization of ethylene and butene-1 is greatly superior to the 0.96 density homopolymer with regard to the stress cracking performance characteristics of insert molded parts.

Improved stress cracking resistance may be obtained with insert molded parts by increasing wall thickness and by the elimination or reduction of the thickness of the knurling. In actual practice, wall thicknesses of less than 0.125" are not recommended for use with insert molding of high density polyethylene.

Aluminum and brass appear to be preferable to steel.

Acknowledgments

The authors express their appreciation for assistance accorded by the Field Technical Service and Application Laboratory of the Celanese Plastics Company in the preparation of this article.

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

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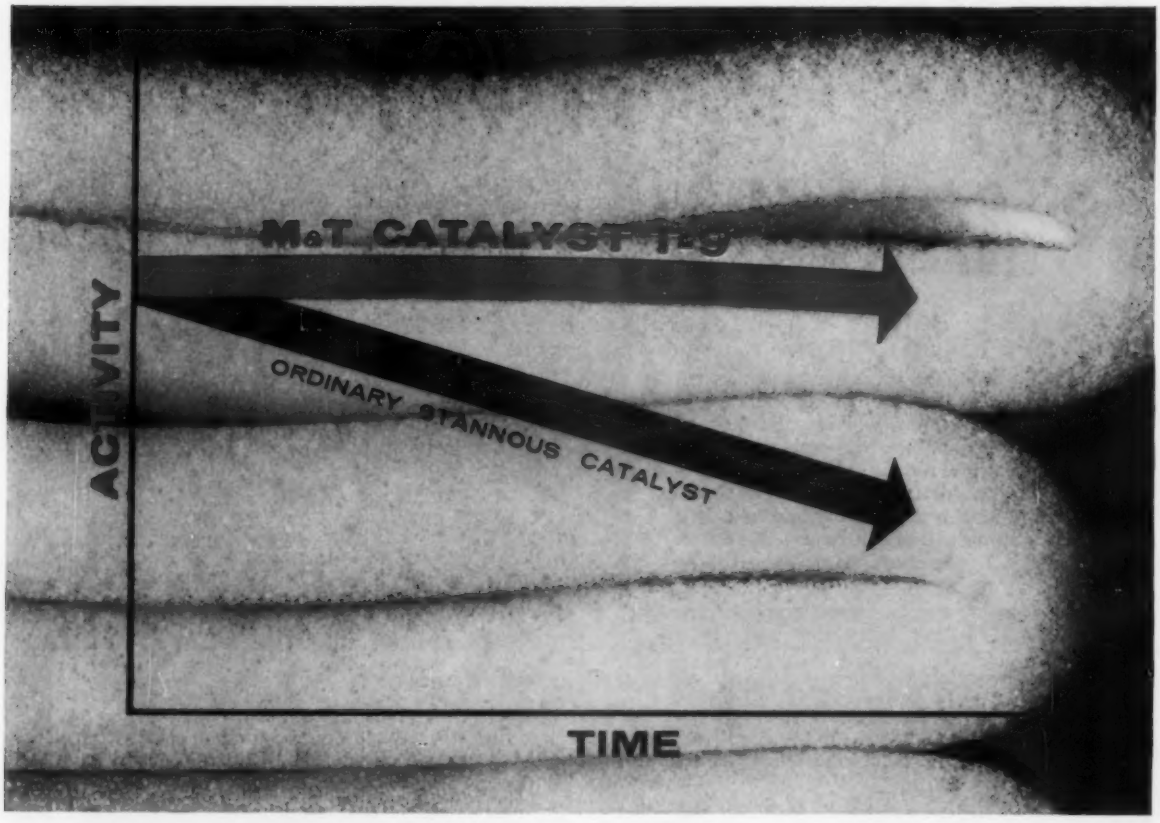

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Figure 1. Possibilities for extruded foams. Left to right—laminate of foam and high impact polystyrene sheets, tubing, rod, and vacuum formed foam sheet.

Controlled Density Polystyrene Foam Extrusion

A new extrusion process which makes possible the production of foamed plastic sheet, tubing, and rod

F. H. Collins
The Dow Chemical Company

Controlled density polystyrene foam extrusion is a process by which polystyrene containing a hydrocarbon foaming agent is fabricated into continuous cross sectional shapes of densities lower than solid polystyrene. Production of parts such as sheet, tubing, and rod are possible by this process. Another tolerance dimension is added to the existing tolerances within which the fabricator works. This additional tolerance is density. It was our purpose to develop a material for and methods of extruding expandable polystyrene materials. The aims were to use conventional extrusion equipment where possible. The density range which can be realized through this process has been determined as have those factors that control the density. The feasibility of utilizing regrind has also been investigated.

Extruded polystyrene foam has several major qualities to offer. Most significant are insulation and low cost. Hot drink cups and certain packaging applications are markets which could utilize the insulative properties of this foam material. Certain core, tubing, rod and sheet applications will use extruded polystyrene foam because of the reduced cost. *Figure 1* shows several of these foam items.

Foams of two density areas have looked promising. One is five pounds per cubic foot which is about the lowest density attainable in this development. The other is at half the weight of polystyrene or 30-35 pounds per cubic foot. The lower density foam has a snow white natural color. It can be quite flexible depending upon orientation. It can be laminated to paper and high impact polystyrene to add insulation and attractiveness to those products. The five pounds per cubic foot foam has a "K" factor in the range of 0.225 to 0.285 depending upon the cell size.

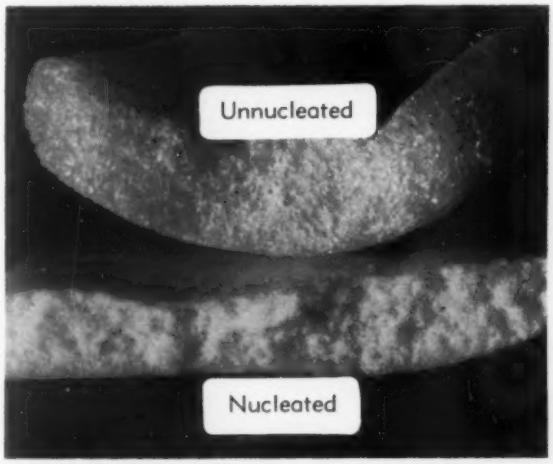

Figure 2. Foamable styrene made with and without nucleating agents.

Table I. Plastic Temperature Versus Density

Plastic Temperature °F	Density, Pounds Per Cubic Foot	Production Rate at 20 R.P.M.* Pounds Per Hour
450	35	126
400	35	128
350	19	114
300	4.6	99
285	4.27	99

* Polystyrene has a production rate of 125 pounds per hour at optimum extrusion temperatures.

Table 2.

Expandable Polystyrene, %	High Impact Polystyrene, %	Density, Pounds Per Cubic Foot
100	—	4-6
75	25	6-8
50	50	11-13
25	75	22-24

Low density tubing has potential for lightweight, low cost conduit or pipe insulation. The tubing can also be used as a core for sales of various sheeting products.

Expandable polystyrene is available in several forms. One is the spherical bead as is commonly used in the foaming-in-place operations. The other is a pellet which our company has developed. It is chemically similar to the spherical bead and its development has been directed toward the foaming-in-place processes. In this extrusion development, however, it has been found that the pellet has performed much more consistently in terms of extrusion throughput and exhibits very little surging. The expandable pellet can be based on either general purpose or rubber modified polystyrene. Rubber modified pellets display greater toughness at both high and low densities.

To extrude expandable polystyrene in either the pellet or bead form as received for normal foaming-in-place operations would result in a large cell foam. The granules are melted and fused within the extruder and will leave the die as a homogeneous gel. The heat subjected to these materials as they pass through the extruder causes the hydrocarbon to become a gas at some point within the system. If the pressures are high enough and the extrusion temperatures low enough the hydrocarbon will not become a gas until it leaves the die orifice. At higher temperatures or low pressures, however, the hydrocarbon may become a gas within the extruder or die. When this change from liquid to gas takes place the hydrocarbon gas forms cells. It does not usually form many cells and much hydrocarbon gas passes into these few cells.

By a process which is termed nucleation, *the extruded polystyrene foam can be produced to have very small cell size*. Nucleation is a process by which the cohesion of the polystyrene is broken up. This involves adding another substance to the expandable polystyrene which will break up the cohesion and form nuclei into which the hydrocarbon gas will pass to produce cells. The more nuclei that are generated, the finer the cell size would be. *Figure 2* shows foamable polystyrene made with and without nucleating agents. The nucleating agent is, therefore, an advantageous member of an extrusion formulation of expandable polystyrene and would usually be utilized in a dry blend form. Many of these nucleating agents will be very fine particles which will dust easily. They would not lend themselves to hopper loading by air conveyance systems due to this dusting. (see box below, left).

Density

Density is expressed in terms of grams per cubic centimeter and pounds per cubic foot. Solid polystyrene weighs

Nucleating Agents

Many substances incompatible with polystrene will act as nucleating agents. This could be crystalline inorganic compounds including pigments, which simply by their incompatible nature or their ability to carry air through the system with them break up the cohesion of the extruded melt and thus nucleate the foam. Chemical reactions liberating gases or water, hydrates of salts which release their water content and compounds which decompose to form gases or water at the extrusion temperature are methods by which nucleation occurs. Nucleation is a subject of much patent activity. The incorporation of incompatible substances for the control of the size of the cells is disclosed in a number of U. S. patents.

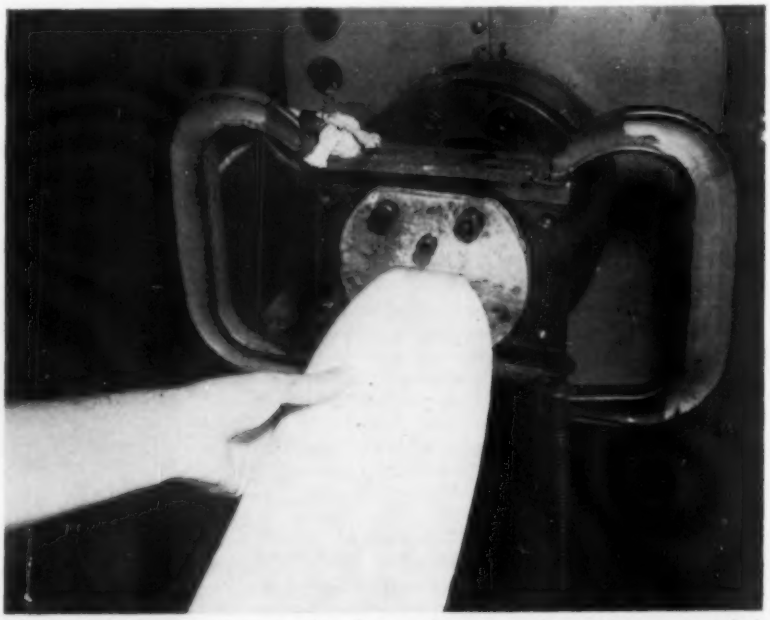

Figure 3. Five pounds per cubic foot polystyrene foam being extruded. Dark area at die orifice is solid polystyrene in which the hydrocarbon has not yet become a gas.

1.05 to 1.06 grams per cubic centimeter and 66 pounds per cubic foot. In this discussion, density will be discussed in pounds per cubic foot.

Density of the extruded foam is primarily controlled by the plastic temperature. High extrusion temperatures produce high densities; low temperatures produce low densities. Densities from four to 35 pounds per cubic foot have been produced according to extrusion temperatures used.

The effect of plastic temperature on density is shown in *Table 1*. The effect that extrusion temperature has on the density of the foam is due to the effect temperature has on both the vapor pressure of the hydrocarbon and the viscosity of the polystyrene. At high temperatures, the polystyrene is low in viscosity, or rather fluid. At the same temperatures the vapor pressure of the hydrocarbon is quite high and easily becomes a gas. In fact the hydrocarbon will escape from the polystyrene primarily by eruption of the cells. At low temperatures, however, the viscosity of the polystyrene will be rather high and the corresponding vapor pressure of the hydrocarbon will be low. In this case the pressure within the extruder is high enough to hold the hydrocarbon in solution until the material has left the die. The hydrocarbon then becomes a gas and the polystyrene foams. The viscosity of the polystyrene is sufficiently high to retain the hydrocarbon within the cells of the foam. At 300°F a die pressure above 700 psi. is sufficient to retain the hydrocarbon in solution.

The addition of a nonfoaming polystyrene (high impact or general purpose) is also a method of controlling density. There could be economical advantages to extend the extruded foam by addition of general purpose polystyrene. The foam could also be toughened by the addition of high impact polystyrene. When these nonfoaming materials are added to expandable polystyrene, more mixing than normal is required to produce a foam of consistent and uniform cell size. *Table 2* shows the effect on density of the addition of nonfoaming polystyrene at a material temperature of 300°F and screw speed of 20 r.p.m.

The utilization of regrind has also been studied and found to be practical. At densities above 20 pounds per cubic foot, the regrind can be handled by conventional methods. The low density foam regrind has presented some extrusion problems primarily because of the bulk factor. It will likely be necessary to crush the low density foam regrind thereby allowing it to feed easier. The addition of regrind to virgin expandable polystyrene can also complicate the nucleation process somewhat.

Equipment

Most conventional extruders should perform satisfactorily with expandable polystyrene materials. The expandable material alone requires little mixing to become an extrudable hot melt. In the case of low density, the mixing must be done at approximately 300°F. Therefore, a vigorous mixing screw such as one fitted with a mixing torpedo would not be suitable. The full flighted increasing root diameter screws as generally used with polyvinyl chloride would be better suited for this low temperature work. Production rates will be limited by screw speed attainable without producing sufficient frictional heat to raise the temperature of the plastic melt and thereby raise the density.

With the addition of certain nucleating agents, nonfoamable polystyrene or regrind, the foam may require more mixing. This extra mixing could be created by producing greater working pressures by means of die design, a screen pack or a valve, or by using a more vigorous mixing screw. This may, however, be at the expense of throughput rates.

Fabrication

It is the basic function of the extruder to melt the thermoplastic as it passes through the cylinder and push the air back through the hopper. The hopper zone of the extruder is normally water cooled. The rear heating zone must be kept cool. At high temperatures in this rear zone the hydrocarbon would be liberated and forced back to the hopper. This usually results in condensation of the hydrocarbon at the water cooled hopper with resultant surging and nonuniform extrusion. If the rear zone is kept at a low temperature it is possible to compress the granules before the hydrocarbon is activated. The air is, therefore, removed but the hydrocarbon continues forward with the thermoplastic. The rear zone temperature of 200°F to 250°F is usually sufficient to prevent the hydrocarbon from being released in the rear zone.

Most extruders have sufficient power for extrusion of expandable polystyrene. The hydrocarbon used in these materials is an excellent plasticizer and allows easy flow of the material at much lower temperatures than could be realized with

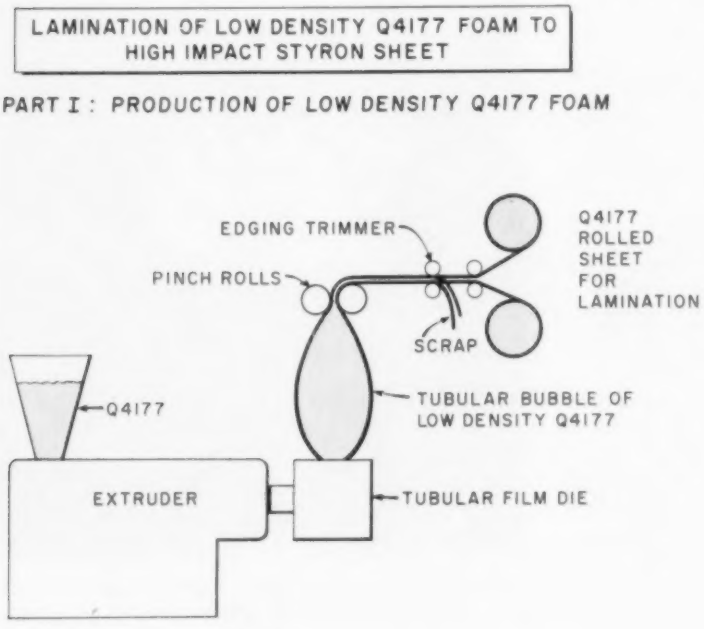
LAMINATION OF LOW DENSITY Q4177 FOAM TO HIGH IMPACT STYRON SHEET
PART I : PRODUCTION OF LOW DENSITY Q4177 FOAM
EDGING TRIMMER
PINCH ROLLS
Q4177 ROLLED SHEET FOR LAMINATION
SCRAP
Q4177
TUBULAR BUBBLE OF LOW DENSITY Q4177
EXTRUDER
TUBULAR FILM DIE

Figure 4. Making a flat sheet from tubular film die.

solid polystyrene. There are, of course, limits to this temperature. Seldom have temperatures below 275°F on the die and front cylinder zone been used due to the high pressures generated.

The low density foam which is produced at approximately 300°F can be made rather flexible by the orientation induced into the material during extrusion and post handling. This extrusion temperature is slightly above the ideal temperatures for orientation of polystyrene. As we have earlier stated, the polystyrene does not usually foam until it has left the die in these low density cases. As these gas cells become larger, they stretch the polystyrene films around the cells. Some orientation is imparted to the polystyrene during this expansion. The temperature at which this expansion takes place and the cell size determine the amount of flexibility or toughness that is induced by orientation.

Inasmuch as this material expands after it leaves the die, it changes in volume by approximately thirteen times. *Figure 3* shows five pounds per cubic foot polystyrene foam having a cross section 6 inches by ¼ inch being extruded from a 2 inch by 0.050 inch die orifice. Note the dark area in the foam at the die orifice. This dark area is actually solid polystyrene in which the hydrocarbon has not yet become a gas.

Solid rod, tubing, or narrow tapes could be produced of low density foam without trouble. However, when this low density foam is produced in wide sheet, wrinkling occurs. The foam expands three dimensionally and the sheeting operation is designed to control only two dimensions. A tubular film die as normally used with polyethylene film is capable of radially stretching the wrinkles from the low density foam thereby producing a flat sheet. *Figure 4* schematically shows this operation. The foam in a tubular film die can be controlled by the trapped air method or by the mechanical sizing devices commonly used in tubing operations. *Figure 5* shows the wrinkles and how they are removed by the tubular process. Biaxial orientation of the foam sheet is possible during this process because of two dimensional stretching. More flexible foams are thus produced.

The best low density foam in terms of surface and uniformly small cell size is produced when the gel leaves the die as a solid with expansion occurring within ¼ inch from the die. This phenomenon is a function of die pressure which in turn is dependent upon die orifice size, plastic temperature, and throughput rate. In support of this belief it is noted that this phenomenon is not easily produced with a large sheeting die. Low densities can be produced through a sheeting die but the surface is rough. Cell size is uniform but not as small as those in parts produced by the small orifice die from which the plastic leaves the die as a nonfoamed melt.

The work with the tape die explains the temperature and throughput functions. At high extrusion temperatures, the extrudate leaves the die similarly to the extrusion from a sheet die—high density with eruption of the cells. A plastic temperature-screw speed relationship exists, however, which causes this high density foam to change to low density foam which leaves the die as a solid. At extremely high plastic temperatures the plastic will foam within the die regardless of screw speed. As the plastic temperature is lowered, however, a direct proportion is found as to the screw speed which will cause this transition from foaming within the die to foaming from without the die. With very small orifices at extremely low temperatures the plastic will foam outside the die regardless of screw speed. To enlarge the orifice size or increase the restriction within the system, such as the addition of a screen pack, would change the temperature-screw speed relationship.

To produce a flat sheet of greater than 25 pounds per cubic foot density would require an extruder die temperature of approximately 375°F. At or above this temperature the foam presents little more difficulty in handling than solid polystyrene. At these higher temperatures, the hydrocarbon becomes a gas within the die and thereby wrinkles little after it leaves the die. Its surface is usually quite rough due to the eruption of the gas cells. Flat sheet dies, polished roll stacks, and rubber draw rolls as commonly used in high impact polystyrene sheet extrusion can thereby be employed. Application of pressure on the foam by the polished rolls can raise the density of the foam. Proper adjustment of this roll pressure can, however, smooth the rough surfaces of the foam without sufficiently raising this density.

Because of the high extrusion temperatures there is practically no orientation of the polystyrene due to the expansion of the cells. We have found it necessary to employ rubber modified materials in order to realize sufficient toughness in this product.

The higher density foams afford rigidity to the product. It vacuum forms almost as well as solid thermoplastic and has sufficient insulation for some applications.

Lamination

Polystyrene foams can be bonded to other sheet materials to produce a better product than either of the materials alone. Flexible low density foam can be laminated to paper to add insulation, attractiveness, and moisture resistance to the paper. A sandwich construction of paper bonded to both sides of low density foam has unusual properties favorable to many packaging and building applications.

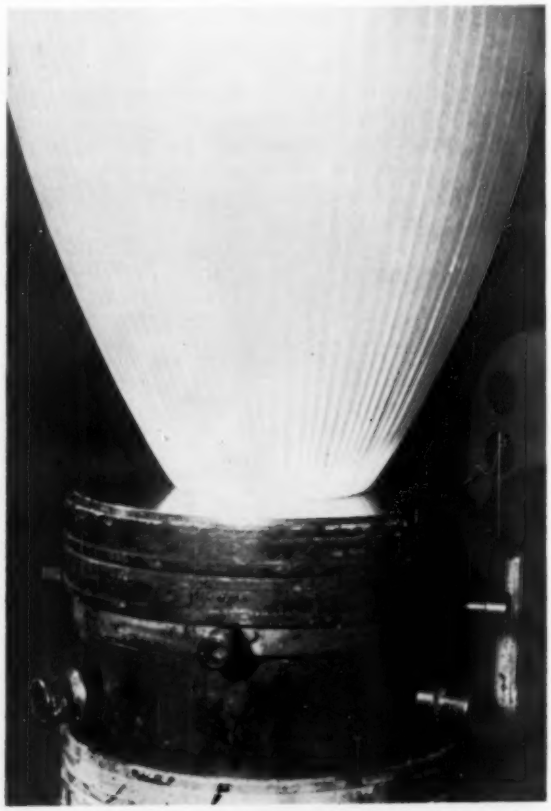

Figure 5. Photograph shows wrinkles and how they are removed by tubular process.

LAMINATION OF LOW DENSITY Q4177 FOAM TO HIGH IMPACT STYRON SHEET

PART II: LAMINATION OPERATION

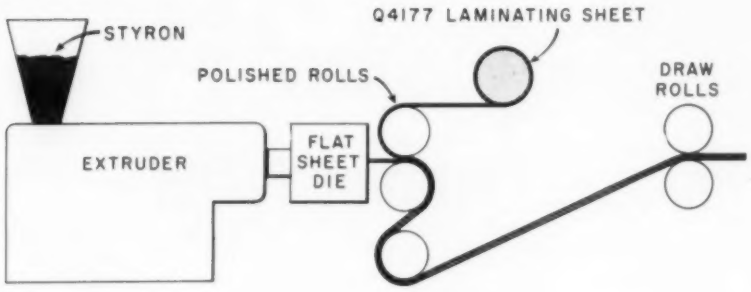

Figure 6. Low density foam when laminated to high impact styrene can be vacuum formed into deep draws.

Low density polystyrene foam can be laminated to high impact polystyrene sheet as the latter is extruded. No adhesive is required for this bond as the high impact polystyrene when extruded has sufficient heat to produce a suitable bond. The foam sheet would be passed into the nip of the polished rolls to bond with the high impact polystyrene similarly to the lamination of biaxially oriented polystyrene films to high impact sheet. Care must be taken in control of roll pressure as excessive pressure could raise the density of the low density foam. *Figure 6* shows this laminating operation. The low density foam when laminated to high impact polystyrene can be vacuum formed into deep draws. The low density foam sheet by itself is not easily formed into deep draws. Also, the high impact polystyrene exhibits the rigidity, toughness, and heat distortion required in many packaging applications. The low density foam would aid in rigidity but more notably would enhance the insulation.

The 30-35 pounds per cubic foot foam can also be laminated to high impact polystyrene by the methods described above but roll pressures are not so critical in this case. A laminate of this type would produce an insulating package fulfilling such requirements as heat distortion, toughness, rigidity, thin wall, and insulation.

Low density foam having thin sheets of high impact polystyrene laminated to both sides produces an unusually low cost rigid sheet. For an example, ¼ inch polystyrene foam with 0.010 inch high impact polystyrene on each side has about the same raw material cost as 0.035 inch solid high impact polystyrene sheet. This laminate sheet shows promise for applications such as display and advertisement signs, and shallow drawn trays. Deep drawn parts have not proven successful to date due to gassing of the foam during heating. Match molding or pressure forming may be suitable forming methods for this laminate sheet because lower forming temperatures and hence less gassing could be used.

Vacuum Forming

Extruded polystyrene foam sheet at the densities previously discussed have been vacuum formed by the same techniques used for impact polystyrene. Difficulty has, however, been encountered in deep draw forming of the lower density sheet. The difficulty lies in the fact that sufficient heat to make the foam sheet form properly can also cause the foam to deorient thereby making a brittle product.

Successful forming of this material has been restricted to shallow straight draws, drapes, and comparatively shallow plug assisted draws. However, higher density sheet has been successfully formed by all the standard forming techniques including deep draw plug assist forming. The container shapes which have been plug assisted from this higher density sheet are the seven ounce tumbler and cottage cheese container.

Vacuum forming of the polystyrene foam-high impact polystyrene sheet laminates are performed in normal techniques. With the low density polystyrene foam, however, the temperature range for optimum forming is rather critical inasmuch as overheating will destroy the foam and insufficient heat will produce poor detail or result in tearing of the foam.

Safety

The foaming agent in expandable polystyrene is a flammable hydrocarbon. Precautions must, therefore, be taken in working with the material. It has been determined that explosive concentrations of the gaseous hydrocarbon exists around the die orifice and around pilings of purge that results from startup. Smoking, welding, and inadequate electrical wiring that may result in sparks should thus be avoided. An exhaust hood directly over the extrusion die for removal of combustible fumes is desirable. A fan blowing across the die can remove these fumes minimizing the hazard, but the room should be well ventilated as with time it would be possible for a concentration of the hydrocarbon to be built up within the whole room.

Conclusions

The extrusion of expandable polystyrene is a new and interesting field. Its low cost, insulation, flexibility, and attractiveness can open many new markets.

A New Test For Polyethylene Printability- The Inclining Platform Tester

T. F. McLaughlin, Jr., *Polychemicals Department E. I. du Pont de Nemours & Co., Inc.*

Instrument provides data which extruders, printers, and converters can use to determine how much preprinting treatment will be necessary

The degree of the treatment on polyethylene surfaces to improve their printability may be measured by several established methods. These include the Cellophane Tape Test (4), the Chapman Test (3), and a test recently described by Wechsberg & Webber (5).

This article describes a new technique which offers a desirable combination of accuracy with speed and simplicity not found in previous methods. In this new test measurements are made on a special instrument of the angles of inclination at which uniform drops of distilled water slide from treated surfaces. These angles are found to correlate with the printability of the surfaces.

Treating Methods for Polyethylene Surfaces

Polyethylene exhibits a wax-like, non-polar surface which is not receptive to most printing inks in commercial use. Numerous treating processes have been devised to alter this surface so that it will become wettable, hence printable and glueable.

A plethora of patents exists covering three fundamental techniques of treating polyethylene surfaces to improve the adhesion of inks.

1. Treatment with oxidizing chemicals with, or without, the catalyzing effect of ultraviolet light.
2. Exposure to various parts of gas flames.
3. Exposure to electrical discharges via corona or contacting surface electrodes.

Of the three fundamental techniques listed, the flame treatment (6, 7) and electrical discharge (8, 9, 10, 11, 12) methods have found the widest commercial acceptance.

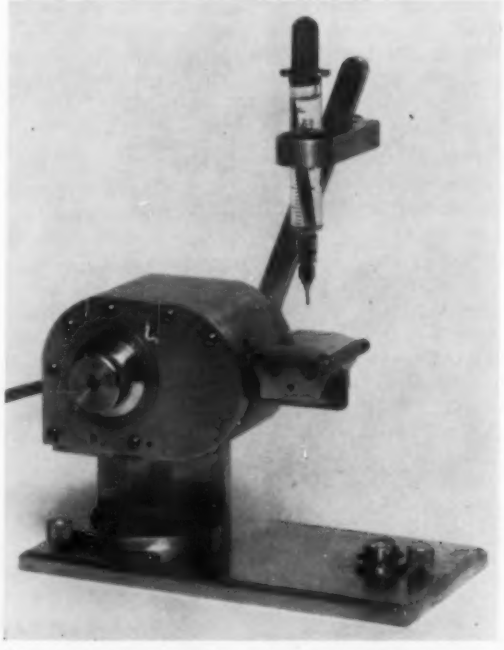

Figure 1. The inclining platform tester. Instrument measures angles of inclination at which uniform drops of distilled water slide from treated plastic surfaces.

The claims in several of the patents for processes to render the surface of polyethylene printable as well as the results of special studies performed by Du Pont's Research Division (1, 2) point to the formation of polar groups in the polyethylene surface structure. These polar groups may be formed by numerous combinations of chemical reactions involving components of the flame, the air, chemical additives, and the polyethylene itself. They are accelerated by the localized intense heat of combustion, by corona, or by photochemical action.

Standard Test Methods

The standard tests commonly used to determine the effect of pre-printing treatments on polyethylene surfaces measure the adhesion of other materials to the treated surface.

Two such tests rate the ability of a treated polyethylene surface to hold a flexographic type ink. The Cellophane Tape Test (4) is a rapid, qualitative evaluation. In this test the tape is pressed against an inked surface and then removed with a quick pull. A rating is given to the amount of ink remaining on the surface. The Chapman (3) Test utilizes the ink as an adhesive between two identically treated film surfaces. An Instron or similar type of universal tensile tester is then used to pull the two surfaces apart giving a quantitative measure of the bond strength.

Another test recently described by Wechsberg & Webber (5) measures the adhesion of a special pressure sensitive tape directly to the treated surface.

Principle of Inclining Plane Printability Test

A satisfactory ink or glue must show an affinity for (i.e. wet) the solid surface upon which it is applied. This affinity to the surface by liquids can be defined in terms of the contact angle formed between the surface and the drop of liquid resting on it (1). Complete wetting occurs when the contact angle is zero while angles greater than zero indicate lesser degrees of wetting. It has been shown that the contact angle of a drop of distilled water resting on a surface of treated polyethylene can be correlated with the final ink adhesion (1). The actual contact angle measurement, however, requires rather intricate and precise optical equipment.

The same wetting of the surface by liquids that defines the contact angle system can also hold the liquid drop in place against the component force of gravity as the surface is slowly tilted at a constant rate from its original horizontal position. The angle of inclination at which a standard size liquid drop begins to move thus becomes another criterion of surface wettability. A more intense surface treatment, inducing greater wettability of the surface to a liquid drop, will require a larger component of gravitational force to cause the standard size liquid drop to slide from the surface. This larger component of gravitational force is obtained by inclining the surface to a greater angle from the horizontal. A correlation is thus obtained between intensity of surface treatment on the polyethylene and the angle of inclination.

The New Instrument

The new instrument and procedures for conducting such angle of inclination measurements are both simple and rapid. A photograph of this instrument is shown in *Figure 1*. The test platform upon which the sample is mounted has a flat section on its surface to serve as a support for flexible materials such as films.

In the starting position, the arm supporting the test platform must be horizontal to give a zero reading on the indicating dial. The test platform can be removed from its supporting arm for mounting of the sample by a spring clip (*Figure 2*). The supporting arm is driven by a small synchronous electric motor with gear train; it moves at a rate of one degree per second. The indicating dial on the side of the instrument is geared to move at four times the speed of the arm hence one complete rotation of this dial corresponds to the maximum inclination of ninety (90) degrees of the supporting arm. The indicating dial is graduated in increments of one degree.

A convenient clutch arrangement on both the supporting arm and dial gears permits manual resetting of these components. This feature adds greatly to the speed of operation of the instrument.

To provide a standard drop of liquid to the sample on the test platform, a small syringe with a shortened hypodermic needle (No. 18) is mounted above. The piston from the syringe is replaced by a flexible rubber bulb to permit the dispensing of individual drops of uniform size. The drop dispensed by this size needle has a volume of 0.02 ml which is one-half that of the standard size dispensed by a laboratory burette (0.04 ml).

Test Procedure

A specimen of treated film or laminate is cut and clamped to the test platform. On this platform a ¾ inch flat area is provided to permit a slight stretching of the film.

The test platform is placed on the end of the horizontal support arm where it is automatically centered and leveled by a key slot. The syringe is positioned directly above the center of the platform so that the drop will fall on the flat section. For best results the tip of the needle should be no more than ½ inch above the surface being tested. To assure uniformity in the sizes of the drops formed from the No. 18 hypodermic needle the first drop to release should be intercepted with the blade of a spatula or piece of paper and the second drop permitted to fall onto the polyethylene surface. For reproducibility of results distilled water was used in all tests conducted with this instrument.

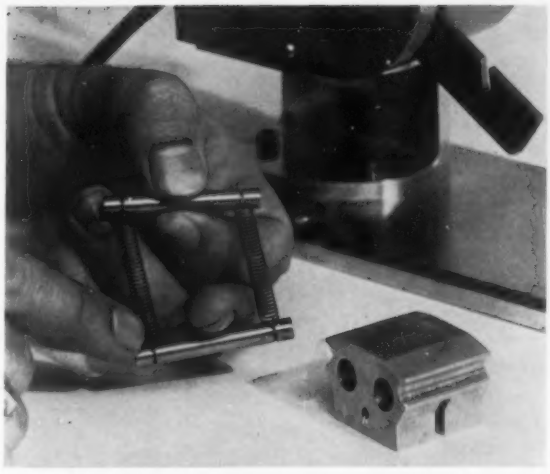

Figure 2. The test platform can be removed from supporting arm for mounting of sample.

With the test platform in the horizontal position and with the dial indicator set at zero the electric drive mechanism is started by pressing the button in the electric cord switch. The supporting arm with test platform tilts at a constant rate of one degree per second until the drop begins to slide down the inclined surface (*Figure 3*). At this instant the stop button is pressed securing the entire mechanism in its inclined position. The angle of inclination can then be read from the indicating dial.

In addition to the intensity of surface treatment a number of variables can influence the angle of inclination at which the standard drop of liquid begins to move on the tilted surface. These variables include the ambient temperature and relative humidity, additives in the base resin, processing conditions of the resin, surface tension of the liquid, and the contact of foreign material with the surface in question. Similarly the accuracy of the test is determined by the tightness of the specimen on the platform and the ability to detect when the drop first moves down the surface. To obtain reproducible data it is important that these conditions be controlled.

Results

Consistent readings were first obtained for the angle of inclination at which a drop of distilled water slid from untreated surfaces of polyethylene film. An untreated sample whose mean angle of inclination measured 19.0 degrees was tested and statistical calculations revealed that 95% of all values were within ± 1.54 degrees.

For treated polyethylene surfaces, a correlation has been shown to exist between the degree of preprinting treatment and the angle of inclination at which a drop of distilled water slides from the surface. The consistency of data obtained seems to confirm the reliability of this test.

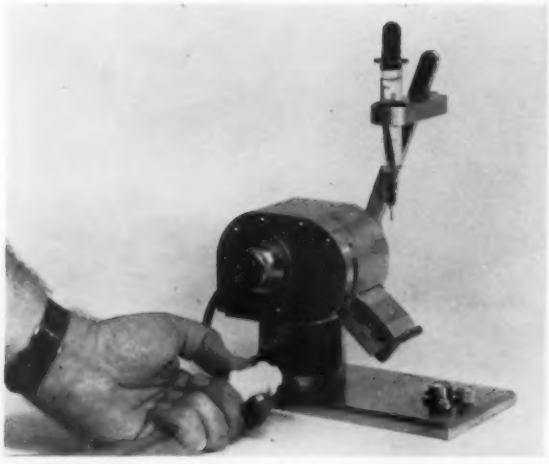

Figure 3. Drop beginning to slide down inclined surface.

The Chapman Test for printability of polyethylene films is generally accepted as the most quantitative ink adhesion test. Samples of treated film which had been graded by the Chapman Test were also graded by this new instrument to obtain a direct comparison. *Figure 4* shows a plot of the angle of inclination vs. the level of treatment on the surface as indicated by the settings on the electrical corona discharge treating unit. *Figure 5* is a plot of the Chapman Peel Test values for ink adhesion vs. the same settings on the treating unit for the identical samples as in *Figure 4*. These data point out the variation in ink receptivity of polyethylene film with increasing intensity of treatment at different film speeds.

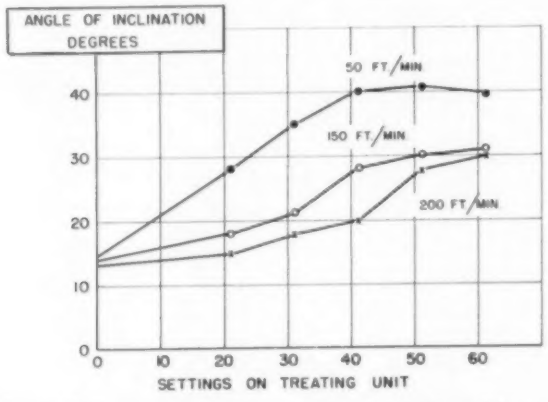

Figure 4. Degree of treatment of polyethylene film as measured by the tilting tester.

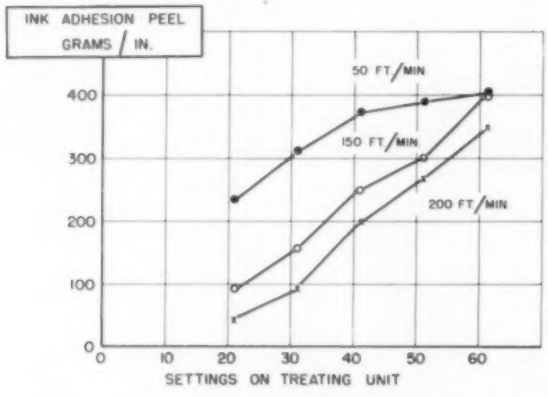

Figure 5. Ink adhesion of polyethylene film as measured by the Chapman Peel Test.

This type of data can be used by extruders, printers, and converters to predict the level of preprinting treatment necessary to achieve adequate ink adhesion. A comparison between *Figures 4 and 5* indicate that this new instrument can be used to measure the extent of preprinting treatments on polyethylene surfaces. Since the affinity of the drops actually gives a measure of wettability over a small area of the film surface, non-uniformity of treatment can be readily detected by a wide variation in data from the same samples.

Other potential uses for this new instrument may be in the determination of surface roughness of untreated polyethylene (a similar technique has already been used to measure the surface roughness of metals (13)), and in the determination of rate of additive migration to the surface of polyethylene film. In this latter case, the parameter of time would be used with the angle of tilt.

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Determination of The Effect of Annealing On Residual Molding Stresses

Method makes possible calculation of amount of residual stress, in p.s.i., in molded plastic articles

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International Business Machines Corp.

In molding thermosetting materials, normal design criteria and specifications are intensified whenever metallic inserts are included in the part. Over the years selection of these criteria and specifications has become commonplace, and a core of empirical knowledge is now available to experienced molders and designers.

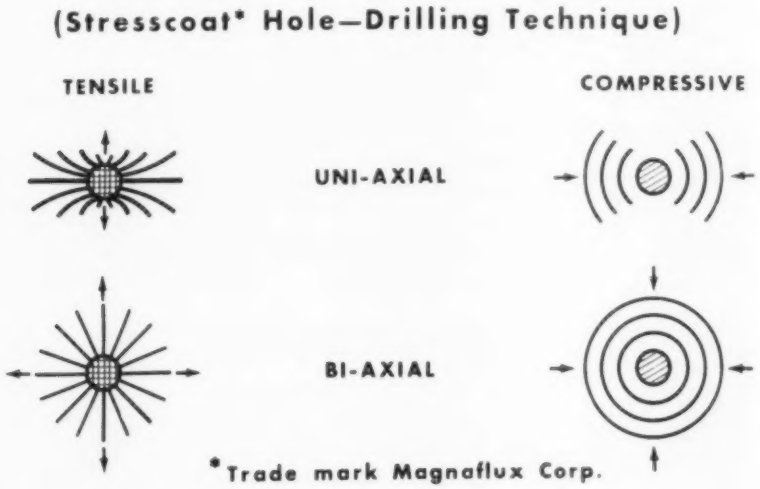
Frequently, however, some design or material precautions taken by molders to avoid cracking are either superfluous or meet with little success. In the latter case, post baking or annealing of the parts is frequently performed. Reliable evaluation of such a procedure often requires large-scale statistical sampling, followed by mass thermal or mechanical shock testing. Such a procedure insures that sufficient reduction of residual stresses has been obtained to prevent excessive cracking in usage.

In the business machine field, molding with inserts is increasing in both volume and number of applications, and many successful part designs deviate from some of the empirical design rules of the past. To facilitate a more scientific solution of future similar problems, a comprehensive program has been set up at IBM to explore the various methods of stress analysis, and apply the results to mold design and material application. An early phase of this program will be discussed in this paper. This method, since it is a direct measurement of residual stresses, avoids costly and time-consuming mass testing.

The Method

The practice of this method involves the use of brittle lacquers, manufactured under the trade name of "Stresscoat"*. These lacquers, or their equivalents, are solutions of wood rosins in carbon disulfide. They have the useful property of being extremely brittle and very sensitive to small strains. The coatings exhibit sharp cracks in a direc-

* "Stresscoat", Trademark of the Magnaflux Corporation, Chicago, Illinois.



◄ **Figure 1.** Idealized residual stress patterns.

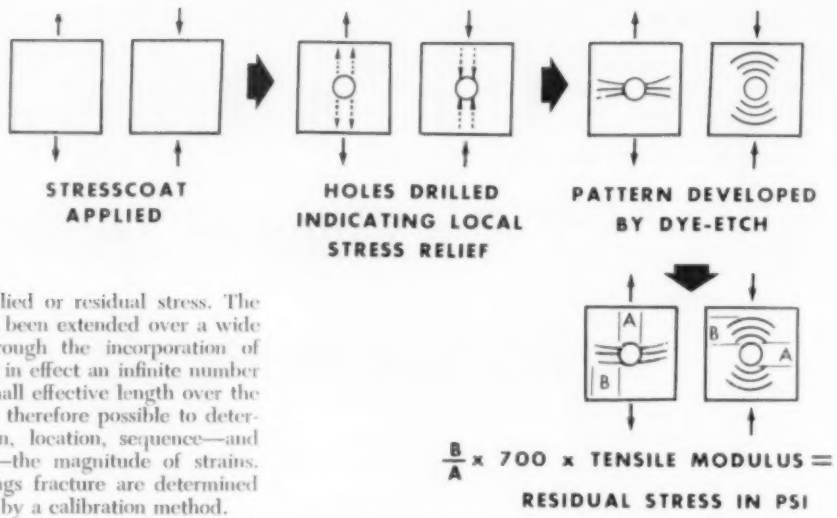


Figure 2. Sample ► residual stress determination.

tion normal to that of the applied or residual stress. The sensitivity of these lacquers has been extended over a wide and clearly defined range through the incorporation of plasticizers. As a result, there is in effect an infinite number of strain gauges of extremely small effective length over the surface of the coated part. It is therefore possible to determine the distribution, direction, location, sequence—and within certain accuracy limits—the magnitude of strains. The values at which the coatings fracture are determined by proper coating selection and by a calibration method.

To visualize this method, we will consider a body in a state of static tension or compression below the elastic limit. If we then remove a small amount of material from this body by drilling a hole, the material immediately around the hole will have its resistance to strain decreased. It will therefore tend to relieve the stress by exhibiting strain until a new static state is reached. If the body has been previously coated with Stresscoat of a proper sensitivity, the coating will crack in a direction normal to the stress and to a distance from the hole which is proportional (1) to the amount of residual stress present. (2) the diameter of the hole drilled and (3) inversely proportional to the tensile modulus of the molding material used. *Figure 1* illustrates the appearance of idealized residual stress patterns for tensile and compressive stresses both in a uniaxial and biaxial direction. In practice, the stress pattern is surrounded by an over-all craze pattern which tends to obscure somewhat the outer boundary of the desired pattern.

Figure 2 is a diagrammatic representation of the method used. The part is initially sprayed with an aluminum lacquer to supply a reflective base for easy observation of cracking. This is followed by a spray application of the correct lacquer to a thickness of 3-4 mils. The selection of the brittle coating to be used is a function of the temperature and relative humidity of the testing environment, and of the particular sensitivity desired. After proper drying, a hole is drilled to a depth equal to the diameter of the drill, usually ⅛". The location of the hole is generally in an area of high stresses, determined either by prior experiments or as visually observed to be the zone most prone to cracking. Immediately after drilling, the area around the hole is sensitized by application of a red dye etchant, or by means of a gentle application of cooled air. In either case, the resultant crack pattern is subsequently made visible by the red dye in order to facilitate observation and evaluation.

The outer boundaries of the crack pattern are then marked for calculation. The calculation is a simple one and consists merely of a multiplication of the ratio of pattern distance over the hole diameter, times a factor of 700, times the tensile modulus of elasticity.

The result is the amount of residual stress present in psi immediately around the periphery of the hole. For greater accuracy, the pattern may be photographed, enlarged, marked, and the required ratio picked off with a scale or a caliper.

Figure 3 illustrates the equipment necessary for simple residual stress measurements. Where the laboratory atmosphere is closely controlled, only one type of lacquer would be necessary. The use of a hand drill or a slow speed power

Figure 3. Equipment ► needed for simple residual stress measurements.

Factors Affecting Accuracy of Method

1. The use of too fast a drilling rate causes local overheating and working of the molding material and may make a contribution which would tend to obscure part or all of the residual stresses.
2. The temperature and relative humidity may change between coating time and testing time. This will affect the sensitivity of the coating used and thus will affect accuracy.
3. Too rapid sensitization after drilling may cause erratic and unduly large crack patterns. This would tend to make interpretation difficult, and results in unduly high stress values.
4. The application of too thick or too uneven a coating of lacquer may result in inaccuracies due to solvent retention, flaking of the coating, or erratic cracking.

Accuracy:

under laboratory conditions, 5-10%
under field conditions, 20-25%

drill is preferable, along with carbide-tipped twist drills. A detailed discussion of spraying technique and testing is given in references 2 and 4.

Due to the highly toxic nature of the carbon disulfide used as a solvent, and its low flash point, extreme care must be taken in practice. It is most desirable to confine all spraying to a well ventilated room, away from all sparks and flames.

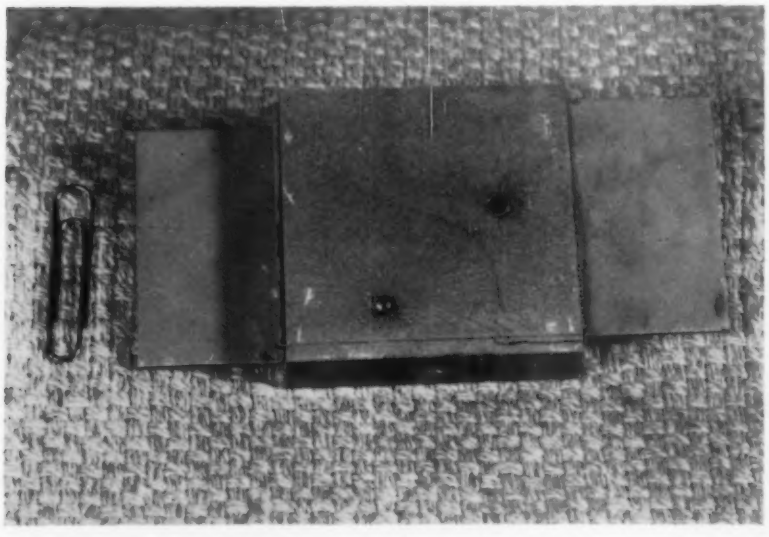
Experimental

To simulate as many design contingencies as possible in experimental stress studies, a transfer mold was designed which yielded a part amenable to the following:

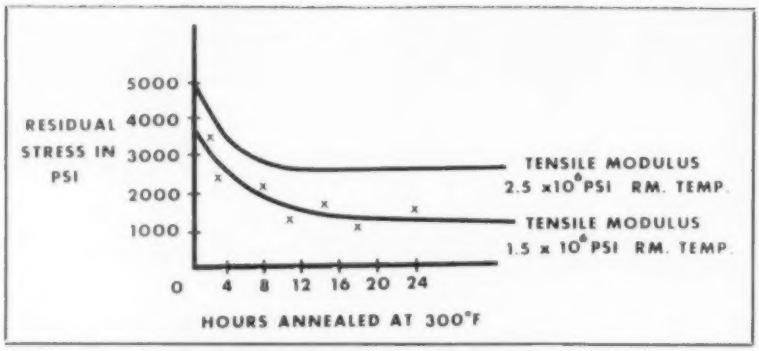
a) Insert cutaway design may be varied.
b) Insert spacing may be varied.
c) The number of inserts may be varied.
d) Insulation thickness over the inserts may be varied.
e) Strain gages may readily be mounted on the part.
f) The inserts protrude in such a fashion that tensile or compressive loads may be applied to the part for measurement of peak stresses using strain gages or birefringent coatings.

Figure 4 is a photograph of a representative test specimen with a fully developed residual tensile stress pattern. This part is transfer molded, since the majority of our insert molded parts are molded using this process. This of course limits the types of materials which can be studied, the types of fillers, and the range of flow of the molding materials. Preforms are used generally with electronic preheating as a step in the process.

Early in the investigation, it was found that the extent of the stress pattern was markedly reduced if the parts were annealed. Since it was felt that this technique might be useful to plastics engineers as a method to evaluate annealing effects, or to establish an optimum annealing schedule, the effect was examined rather closely. *Figure 5* is a curve of residual stress plotted against annealing time at 300°F. Note that the major annealing effect occurs in the first 6-10 hours. At lower temperatures, the drop is much less steep. There appear to be differences in residual stress behaviour between high and low modulus materials under the same experimental conditions. It can also be seen that the initial residual tensile stresses may come dangerously close to the actual tensile strength of the material. In this case, any appreciable thermal or mechanical shock would tend to crack the part. This has been observed in experimental work. In some cases where low strength material was used, no uncracked parts could be molded unless a fairly thick plastic layer was used, and annealing was done immediately after molding. *Figure 6* illustrates this point rather graphically. This is a plot of residual stress against annealing time at 300°F. for several material thicknesses over the inserts. The effect on crack resistance of increasing the material thickness is well known. However, quantitative or even semi-quantitative data on this effect has been lacking. Note that as the material thickness increases, the initial residual stress was lower, but the drop-off occurs within the same annealing time span. At thicknesses above ⅛", little improvement was obtained by annealing. The decrease in measured residual stress was linear over the thickness range studied. This is shown in *Figure 7*.



◄ **Figure 4.** Representative test specimen with a fully developed residual tensile stress pattern.



◄ **Figure 5.** Residual stress vs. time of annealing at 300°F.

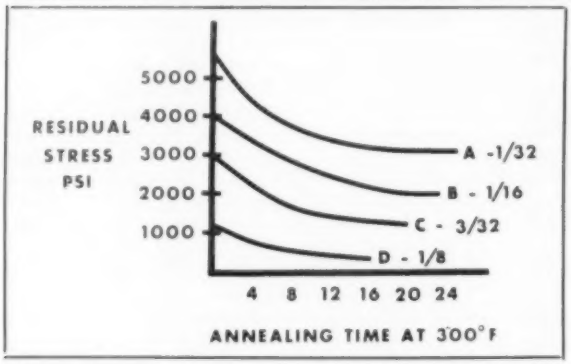
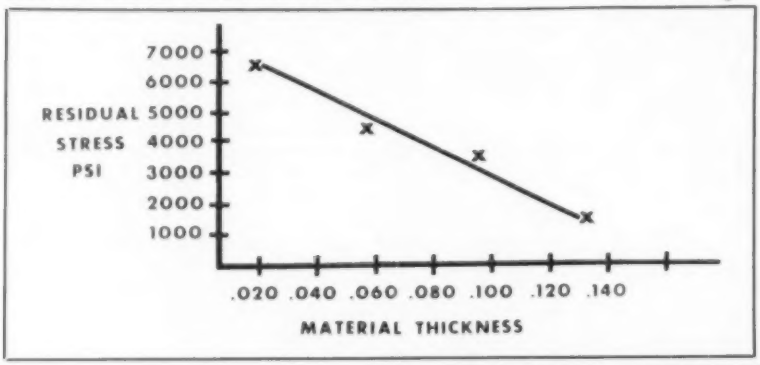


Figure 6. Residual stress vs. annealing time for different insulation thickness over inserts.



▲ **Figure 7.** Residual stress vs. material thickness over metallic insert.

Some work on actual production parts has been done. One of these parts is shown in *Figure 8*. This part has a very high volume density of metallic inserts. The two flat sides are brought to dimension by machining. After machining it was found that the angular distribution of dimensions was changing due to the part stress relieving itself as a result of material removal. An annealing schedule determined by this method was given prior to machining. Marked improvement in this tendency resulted.

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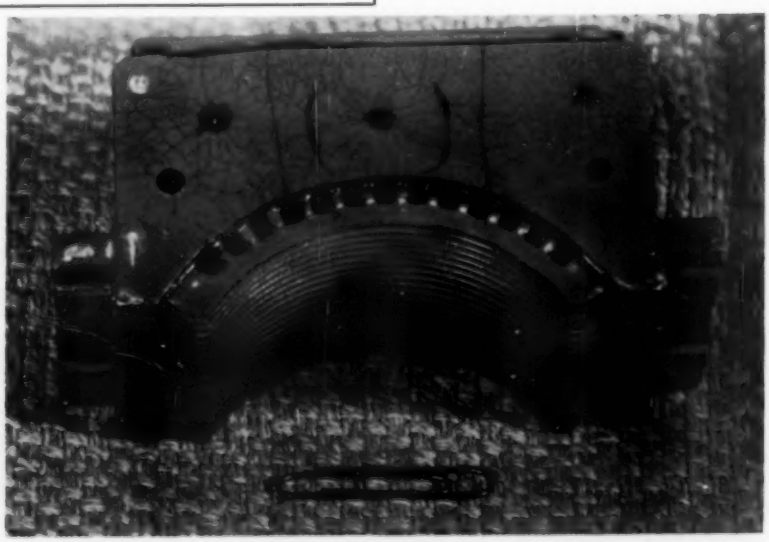

Figure 8. Production ► part showing residual stress pattern.

Formulation of Polyamide-Epoxy Fairing Compounds for Automobiles

D. E. Peerman and D. E. Floyd

Journal Series No. 234

Research Laboratories, General Mills, Inc.

There are two general types of organic solders (fairing compounds) to be considered for use on automobiles, the polyester type and the epoxy type (1). The first type, polyester-based, is used to some extent in the repair and maintenance field because it is low priced and quick setting. It has the disadvantages, however, of having relatively poor adhesion, a high degree of brittleness and mediocre workability. It is generally considered unsatisfactory for new-car production.

The second, or the epoxy type of organic solder, is the type which currently has the greatest chance of succeeding in the quality-conscious, new-car field. The commonly used amine and anhydride type curing agents, which are successful in other epoxy applications, are not satisfactory for use in an epoxy plastic solder. The acid and anhydride types of curing agents, for instance, are far too slow for the automobile production line since they require temperatures of at least 300°F. for long periods of time to obtain a satisfactory cure. The short chain amine hardeners, on the other hand, are too slow at room temperature and too fast at elevated temperatures. If allowed to cure at room temperature, they would require 20 to 30 minutes minimum, and this, of course, is far too long for the production line type of assembly. If heated to elevated temperatures to hasten the cure, the heat of exotherm causes blowing, air bubbles, and charring.

The coreactant most promising for use with epoxies to form high quality body solders are polyamide resins (2). By using approximately equal portions of Versamid 125* with low molecular weight, fluid epoxy resins, it is possible to obtain cures in 2 minutes or less by several practical means.

* Versamid is the trademark for polyamide resins produced by the Chemical Division of General Mills, Inc.

Formulating A Plastic Solder

A plastic body solder based on polyamide-epoxy blends has four major components:

1. Versamid Resin 125, a polyamide resin
2. Epoxy resin (low molecular weight, undiluted)
   - Bakelite's ERL-2774
   - Ciba's Araldite 6010
   - Shell's Epon 828 or Epon 820
3. Fillers
   - Kaolin type clays (Georgia Kaolin Company or Aluminum Flake Company)

DESIRED HANDLING CHARACTERISTICS OF PLASTIC FAIRING COMPOUNDS

1. Component Ratio, 50/50
2. Adequate Trowelability for Application
3. Good Thixotropy to Control Flow
4. Contrasting Color in Components for Easy Identification and Visual Blending Efficiency Check
5. No Foaming On Cure

PHYSICAL REQUIREMENTS

1. Strong Adhesion to Body Steel
2. High Impact Resistance
3. Resistance to Dinging
4. Low Temperature Shock Resistance
5. Paintability
6. Uniformity

Atomized Aluminum (Metals Disintegrating Company, Alcoa and Reynolds)
Black Iron Oxide (Metals Disintegrating Company)
Sponge Iron (Hoeganaes Sponge Iron Company)

4. Thixotropic Agents
Bentones 34 & 38 (National Lead Company)
Amorphous Silica (Cabot, Monsanto & Davison)
Carbon Blacks (Binney & Smith, Cabot)

The general formula leaves many blank places which must be filled in before a finished plastic solder can be produced. The ratio of polyamide to epoxy resin must be determined, the amount and exact type of fillers to be added must be determined (3), and the correct amount and type of thixotropic agent must be accurately established. Each of these variables must not only be determined alone, but in relationship to one another. For instance, the optimum ratio of one particular type of filler may influence the amount and type of thixotropic agent to be used so that the formulation does not sag under heat. Likewise, the ratio of polyamide to epoxy may limit the amount and type of filler which can be used to impart the right amount of impact resistance, heat transfer, coefficient of thermal expansion and other properties which must be considered.

In choosing the most favorable type and amount of filler to be added to the composition, we have utilized the Latin Square experiment design. In this series of experiments the amount of filler corresponds to the ordinate and the type of filler to the abscissa. In this way, two variables can be checked at once thus saving much needless experimentation in which one variable is controlled and the other held constant. A typical experiment design in the amount and type of filler is shown.

THE EFFECT OF FILLERS ON IMPACT STRENGTH

Filler	10%	30%	50%	70%
	Impact (Resistance) Values in Pounds			
Aluminum	0.7	1.8	2.3	1.1
Iron Oxide (Black)	4.0	4.0	1.8	1.7
Kaolin Clay	1.7	1.7	1.2	3.1
Aluminum/Clay Blend, 1:1	2.3	2.1	2.0	1.3

(Average of Entire Set = 2.0)

Deviations From The Average

					Sum
Aluminum	−1.3	−0.2	0.3	−0.9	−2.1
Iron Oxide (Black)	2.0	2.0	−0.2	−0.3	3.5
Kaolin Clay	−0.3	−0.3	−0.8	1.1	−0.3
Aluminum/Clay Blend, 1:1	0.3	0.1	0	−0.7	−0.3
Sum	0.7	1.6	−0.7	−0.8	

In this case the amount and type of filler has been judged by its resistance to impact. In other tests other criteria are used, such as adhesive strength or resistance to dinging. The values in the table are the weights of steel balls which cause failure on impact. All tests have been run in duplicate and the average of the two readings taken. After taking the average of the entire set of measurements we subtract the individual measurements from the mean. Adding these results in horizontal and vertical columns we find that the type and percentage filler is thus easily chosen from any group of measurements. In the case in point, 30% filler level is the optimum filler level and iron oxide is chosen from the four fillers as the best in resistance to impact.

Combinations of fillers frequently give results not obtainable through the use of a single filler. Choosing the best ratio of filler in a mixture is simplified by using the Latin Square technique.

THE EFFECT OF FILLER BLENDS ON ADHESION

Blend	30%	50%	70%
	Bend Strength Values in Pounds		
Alum./Clay, 1:3	155	180	150
Alum./Clay, 1:1	100	95	120
Alum./Clay, 3:1	200	175	175

(Average for Entire Set = 150 lbs.)

Deviations From The Average

				Sum
Alum./Clay, 1:3	5	30	0	35
Alum./Clay, 1:1	−50	−55	−30	−135
Alum./Clay, 3:1	50	25	25	100
Sum	5	0	−5	

Data above show the values of standard temperature bend strength obtained using three mixtures of aluminum and Kaolin clay. Each of the mixtures was added in three concentrations—30, 50, and 70%, Again the average of the entire set is taken and the deviations from the average are calculated. Adding the vertical and horizontal columns, we come up with the finding that 30% filler level is optimum for this blend and that the ratio of three parts aluminum to one of clay is the best of the three mixtures tried.

If we run the same mixtures, judging the results by impact strength instead of standard temperature bend strength, we obtain a square as shown below.

THE EFFECT OF FILLER BLENDS ON IMPACT RESISTANCE

Blend	30%	50%	70%
	Impact Values in Pounds		
Alum./Clay, 1:3	4.0	6.3	3.1
Alum./Clay, 1:1	2.1	2.0	1.3
Alum./Clay, 3:1	9.4	5.1	1.5

(Average of Entire Set = 3.9)

Deviations From The Average

				Sum
Alum./Clay, 1:3	0.1	2.4	−0.8	1.7
Alum./Clay, 1:1	−1.8	−1.9	−2.6	−6.3
Alum./Clay, 3:1	5.5	1.2	−2.4	5.3
Sum	3.8	1.7	−5.8	

In these two series the impact strength and the adhesive strength become optimum at the same filler level and with the same ratio of filler mixture. This is not always true. A compromise between obtaining impact strength or, for instance, greatest adhesion, sometimes has to be made.

By applying the above principles to a large number of mixtures or fillers, trying each at varying percentages, the optimum fillers and percentages are obtained. Since fillers constitute only one of the component variables in the four-fold plastic body solder, the correct ratio of polyamide to epoxy resin in the formulation must also be chosen.

To obtain a thermosetting product having the highest heat distortion temperature a product containing 35% polyamide and 65% epoxy would be used. This composition, however, would give a plastic body solder which is far too rigid for the service conditions which it will undergo. It is necessary to use more polyamide than normal in body solder compositions to obtain the correct degree of toughness and extensibility. As the percentage of polyamide is increased, the compositions become tougher and less rigid. The less rigid the composition becomes, the greater is its extensibility. This property is exactly that which is required when good dinging resistance is desired. To obtain the maximum degree of dinging resistance the percentage of polyamide to epoxy would be increased until the composition contains 60 to 70% polyamide by weight; however, many considerations must be kept in mind during any formulating change in plastic solder.

If a very large percentage of polyamide were used in the composition, good results in extensibility of ding resistance would be achieved; however, impact strength at low temperatures would be lost. Strangely enough the two properties become optimum at different ratios of polyamide-epoxy. To obtain good low temperature impact resistance it is necessary to maintain a fairly high percentage of epoxy resin in the composition. The exact ratio of polyamide to epoxy must be determined by the end use and customer acceptance (4).

Thus far, the methods of choosing the most favorable fillers and filler content have been discussed and it has been shown how the optimum polyamide to epoxy resin ratio may be obtained. The next major constituent to consider is the thixotropic agent. Having done this we will have shown the routes to selecting each of the four basic ingredients in the plastic body solder.

In choosing the best thixotropic agent for the plastic solder, it is well to remember that this is a two-component system, one containing the polyamide resin, the other containing the epoxy resin. A thixotropic agent which may be effective for one resin may not be effective for the other. In the case of thixotropic agents as in ratios of resins a compromise is often necessary. There are problems to be overcome in using any of the well known thixotropic agents. For instance, although Bentone 34 is an excellent thixotropic agent for both polyamide and epoxy, it imparts to the finished composition a brittleness which makes it difficult to pass the ding resistance test.

Since the polyamide can absorb moisture from the air in humid weather, care must be taken during storage of the polyamide and of solder components which contain it to avoid unnecessary exposure to moist air or moisture itself. Containers should be kept closed. Precautions need to be taken also during the processing of plastic solder formulas, such as during the blending of fillers into Versamid 125 on a three-roll mill or other mixing equipment where a large surface area is exposed to the air. Absorption of moisture or entrapment of air can later lead to foaming during cure, as with any volatile material, and the foaming introduces numerous problems which have already been discussed. Thus, by observing the correct manufacturing procedures as dictated by the chemical and physical properties of the ingredients, it is possible to achieve an organic solder of high quality and uniform characteristics.

Literature References

1. Coffin, J. G., "Advances in Plastics for Automotive Body Manufacturers" (unpublished to date).
2. Peerman, D. E., Floyd, D. E., and Mitchell, W. S., *Plastics Technology*, *2*, (1), 25 (1956).
3. Technical Bulletin 11-F-1, General Mills, Inc.,
4. Peerman, D. E., *Materials and Methods*, *44*, (1), 106 (1956).

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Correction

Blow Molding Equipment Directory

Boston Plastic Machinery, Inc. was erroneously listed as a blow molding equipment manufacturer in last month's directory (page 628). Actually, this company merged last February with Modern Plastic Machinery Corp., 64 Lakeview Ave., Clifton, N. J., and Boston Plastic no longer exists.

Modern Plastic Machinery Corp. manufactures twin-station blow molding equipment capable of producing up to 1500 round containers (4-oz.) per hour. Air requirements are 15 cu. ft. per minute at 135-200 lbs. main line pressure. Maximum mold dimensions are 28" daylight; 36" long; 21" wide; 12" stroke. Parison size: From ¼" O.D. to 6½" O.D.

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Cold Plunger Molding of Thermosets

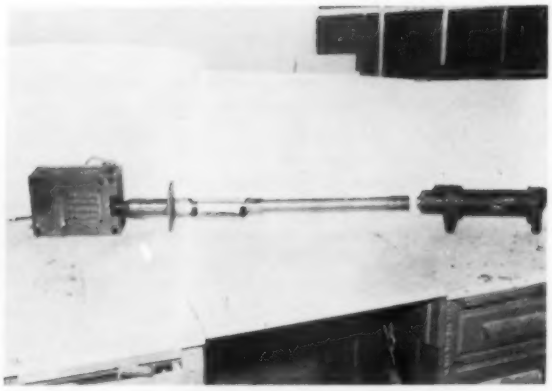

Figure 1 illustrates diagramatically all essential features of the process. From left to right are shown one half of a four cavity mold with runners and conical orifice, the plunger cylinder containing a charge of compound in cut rope form, the plunger ram and finally the plunger hydraulic cylinder. The parts are shown unassembled for ease of visualization.

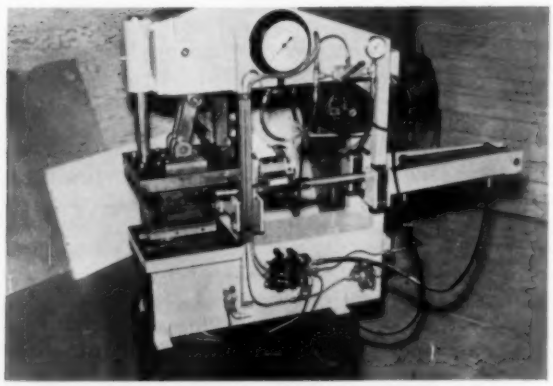

Figure 2 shows the parts assembled in a small laboratory toggle press which provides the mold clamping pressure. In the back center the general arrangement of an automatic loader may be seen.

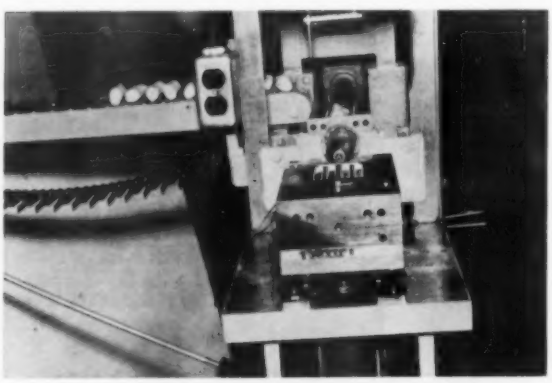

Figure 3 another view of the automatic loader is shown as well as a clear view of the plunger nozzle and the mold cavity. The upper mold half has been removed in this view.

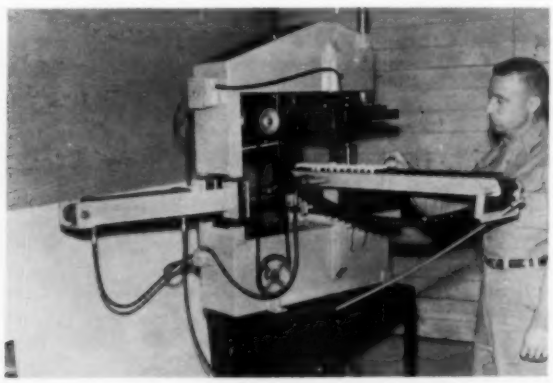

Figure 4 illustrates manual charging of the automatic loader. The small magazine with which this laboratory press is equipped can be charged with sufficient compound, in the form of pre-cut rope, for one hour's operation in less than one minute. Commercial presses have been equipped with automatic loaders of sufficient capacity for eight hours automatic operation on small moldings and these require about ten minutes for manual recharging.

The Sequence of Operation is as Follows:

The mold is closed and clamping pressure is applied, the plunger ram is advanced which first brings the cylinder nozzle against the conical orifice of the mold then during a dwell period of from 4-8 seconds injects compound into the mold cavities. The plunger is then retracted sufficiently to remove the nozzle from contact with the mold. The floating cylinder is allowed only from ½ to 1 inch of free travel between stops. Friction of plastic between the plunger and cylinder is sufficient both to advance the cylinder and to retract it on the corresponding motions of the plunger ram. When the charge of compound in the plunger cylinder is nearly exhausted, after from 5-20 molding cycles depending on the plastic requirements of the mold, the plunger retracts fully and the cylinder is automatically recharged. No loss of cycle time is involved in recharging the cylinder.

Pictures and sequence of operation (page 720) describe this new molding process—limited in application now—but maybe capable of molding phenolic and melamines one day soon.

Dr. A. M. Howald
Glaskyd Incorporated

This article describes a more easily automated plunger molding method* developed primarily for glass fiber alkyd compounds as produced in extruded rope form. Molds are designed exactly as for hot plunger molding excepting that the sprues end in a conical injection orifice at the mold parting line, rather than at a plunger cylinder.

In the molding operation a floating cylinder with a semi-spherical injection nozzle is brought against a conical mold orifice, the plastic is injected into the mold and the nozzle withdrawn after a few seconds of contact. The plunger cylinder, after from five to twenty molding cycles is re-charged by dropping a cylindrical charge of plastic into a trough-like center section of the cylinder.

Plunger cylinder temperatures of from ambient to as high as 170°F. may be used without danger of pre-cure in either the cylinder or orifice. Other anticipated possible difficulties such as back flow after retracting the nozzle have not materialized.

In commercial application a number of advantages over hot plunger molding have been observed:

1. Cycles per hour are from 1/3 faster to twice as fast as hot plunger molding permitting fewer mold cavities.
2. The method is more easily automated as recharging is infrequent and accuracy of weight charged is immaterial.
3. There is less waste of compound as there is no loss of cured material in cake form.
4. Quality of parts produced is equal to and in most cases superior to hot plunger molded parts.

It should be noted that the full injection pressure in this operation is exerted on the mold orifice and plunger nozzle. With both parts of hardened and ground tool steel this is permissible with injection cylinders up to about 2 inches in diameter and of any reasonable length. Should machines of larger injection capacity be contemplated it would be necessary to apply separate hydraulic cylinders to engage the nozzle and orifice and to transfer the plastic. This precaution would eliminate danger of crushing the relatively small cone and nozzle.

Mold clamping pressure from 1-2 tons per square inch of projected mold area, all cavities and lands included, are required and injection pressures of from 2-4 tons per square inch should be available.

As additional commercial applications of the process are developed it is contemplated that clamping pressures for multiple cavity molds will be applied by conventional hydraulic presses and that indexing machines with from two to six stations will be used where insert loading is involved. The injection equipment would be essentially identical in both cases.

* U.S. Letters Patent No. 2,738,551 March 20, 1956 covering the process has been granted. GLASKYD is prepared to issue royalty free licenses to interested fabricators.

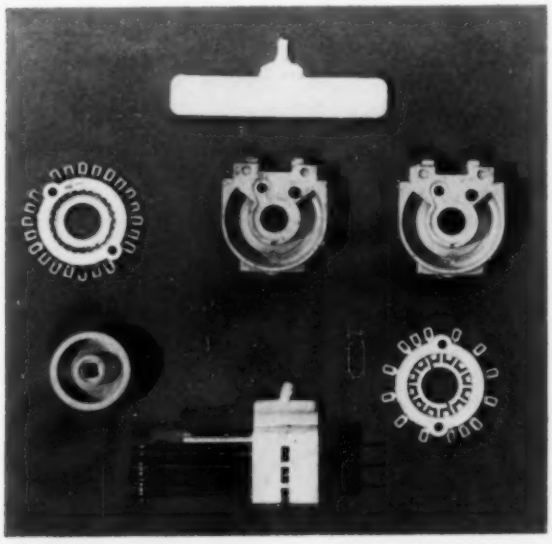

Figure 5 shows a number of parts which have been molded of GLASKYD by this process. Sprue losses vary from less than one percent on single cavity molds up to 55 percent on multiple cavity molds producing very small parts. In all cases the loss is much less than for hot plunger molding and has varied from 1/5 to 1/2 as much.

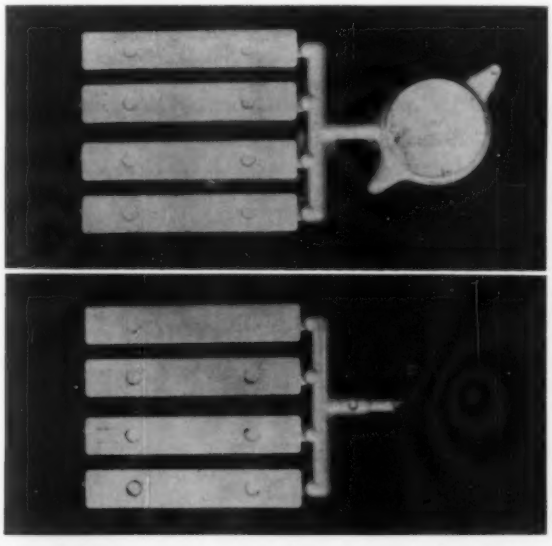

Figure 6 shows parts and sprues obtained by cold plunger (lower) and hot plunger (upper) molding of identical parts. In this case the mold has been designed to be reversible in order that it may be used interchangeably by the two molding methods. Material loss by the cold plunger method on these parts is 13 percent, by the hot plunger method 49 percent of the weight of the finished parts.

New Epoxy Molding Compounds

Epoxy Molding Compounds . . .

closely approximate phenolics in molding techniques
are inert in comparison to other plastics
have no by-products involved or given off
can be molded at low pressures . . .

They Could Mean for the Industry . . .

low die costs
molding around tiny pin holes, ceramic walls, wiring, etc.
lasting electrical and mechanical properties
encapsulation by conventional molding techniques
a material with lasting dimensional stability . . .

Paul E. Fina
The Fiberite Corporation

Epoxy molding compounds are the latest addition to the thermosetting conventional molding field. On an individual property basis there are other molding compounds which may have an equal or better property, but from an all around standpoint, epoxy molding compounds should be considered an important addition to the field.

What They Offer

A detailed explanation of what epoxy molding compounds offer to the molding industry is necessary in order that these compounds find their proper place in the field. Some of the outstanding characteristics of epoxies are developed below:

- **Inherent dimensional stability**
  1. Cure involves a complete addition type chemical reaction with no by-products given off and no volatiles involved.
  2. Adhesion to reinforcing filler of epoxy resins result in wedding the resin and filler/reinforcement into an optimum integral mass.

- **Molding pressures as low as fifty p.s.i.**

  Unique melt viscosity coupled with a sharp gelation allows epoxy molding materials to be formulated for exceptionally long flow into thin sections and around delicate inserts.

  The effect of draw in the part to be molded is not nearly as critical as with other thermosetting materials due to the sharp gelation characteristics.

  Transfer pressures may be low because of the low initial melt viscosity of the epoxy bonded molding materials. Molds designed for easy flow general purpose phenolics are a good starting point.

  Runners should be kept small for medium and low impact epoxy materials to build up back pressure.

  Rate of flow (especially in transfer molding) should be slowed to prevent air entrapment (formation of bubbles), maintain a smooth fill of the mold cavity and achieve optimum molded density.

- **Maximum retention of electrical properties.**
  1. Cure involves an addition reaction with no by-products released, such as ammonia or water, as in some other molding compounds.
  2. Adhesion of epoxy resin to filler/reinforcement precludes moisture absorption by the normal capillary effect.
  3. Ether linkage formed in cross linking during cure is notably stable to chemical action. As a result, products of degradation are held to a minimum which maintain electrical properties under the effect of high heat and/or humidity.

- **Maximum retention of mechanical properties.**
  1. Excellent adhesion of epoxy resin to filler/reinforcement.
  2. No volatile entrapment to interfere with function of filler/reinforcement under adverse conditions of heat and moisture.

- **Chemical resistance.**

  Resistance of ether linkage to chemical attack, particularly hot caustic solutions, is unique for thermosetting materials.

Acknowledgment

The assistance of Robert Werkheiser, Research Director, Fiberite Corp., is appreciated.

Comparing Epoxy with other Molding Compounds*

Property	Units	General Purpose Mineral Epoxy	Asbestos Melamine	General Purpose Alkyd-1	General Purpose Alkyd-2	General Purpose Diallyl Phthlate	General Purpose Phenolic	General Purpose Silicone
Flexural Strength	psi.	11,500	7,500	7,000	6,000	7,500	8,500	6,500
Flex. Mod. of Elast.	psi.	2.2×10^6	1.8×10^6	2.1×10^6	1.9×10^6	1.2×10^6	2.0×10^6	1.0×10^6
Flex. Work to Break	Ft.lbs.	0.144	.073	.062	.049	.12	.16	.11
Maximum deflection	MILS	57	45	35	35	70	65	70
Izod Impact Strength	ft.lbs./inch of N.	0.35	0.31	0.32	0.35	0.29	0.35	0.32
Heat Distortion Pt.	C	110°C.	130°C.	165°C.	165°C	—	150°C.	250°C.
Measured at 23°C.								
Volume Resistivity—Megohn-CM.		9×10^9	3×10^7	3×10^7	3×10^7	3×10^7	3×10^7	3×10^7
Power Factor @ 60 cps.		.011	.064	.040	.035	.043	.024	.0045
Power Factor @ 1 K.C.		.019	.037	.023	.025	.044	.023	.0044
Power Factor @ 1 M.C.		.013	.030	.015	.013	.048	.012	.0065
Dielectric Constant @ 60 cps.		4.4	7.2	6.2	5.8	6.2	5.2	4.8
Dielectric Constant @ 1 K.C.		4.2	6.7	5.7	5.4	5.7	4.8	4.8
Dielectric Constant @ 1 M.C.		4.1	5.7	5.3	4.9	4.6	4.3	4.6
Measured at 100°C.								
Volume Resistivity—Megohn-CM.		5×10^7	6×10^6	3×10^7	6×10^6	3×10^7	1×10^5	3×10^7
Power Factor @ 60 cps.		.032	TOO HIGH TO MEASURE	.080	.110	.103	.32	.011
Power Factor @ 1 K.C.		.028	.234	.065	.071	.072	.089	.0080
Power Factor @ 1 M.C.		.016	.047	.026	.027	.096	.027	.0080
Dielectric Constant @ 60 cps.		4.9	TOO HIGH TO MEASURE	7.8	7.4	7.6	7.0	5.0
Dielectric Constant @ 1 K.C.		4.6	9.4	6.9	6.3	6.5	5.5	5.0
Dielectric Constant @ 1 M.C.		4.3	6.3		5.3	6.4	4.6	4.8
Measured at 200°C.								
Volume Resistivity—Megohn-CM.		5×10^4	3×10^3	5.7 3×10^4	6×10^3	9×10^4	9×10^2	5×10^5
Power Factor @ 60 cps.		.35	TOO HIGH TO MEASURE	TOO HIGH TO MEASURE	TOO HIGH TO MEASURE	TOO HIGH TO MEASURE	TOO HIGH TO MEASURE	.042
Power Factor @ 1 K.C.		.084	.384	.158	.286	.248	.66	.021
Power Factor @ 1 M.C.		.019	.043	.044	.035	.176	.198	.010
Dielectric Constant @ 60 cps.		5.9	TOO HIGH TO MEASURE	13.4	TOO HIGH TO MEASURE	13.0	TOO HIGH TO MEASURE	4.9
Dielectric Constant @ 1 K.C.		5.1	8.2	9.2	7.6	8.9	66.8	4.8
Dielectric Constant @ 1 M.C.		4.3	5.1	7.1	5.3	9.2	6.4	4.5
Arc Resistance Secs. (1)		180	180	180	185	140	80	300

(1) The arc resistance was measured at 23°C.
* Data compiled by Fiberite Corporation—Winona, Minnesota; all comparisons are for equal grades of impact.

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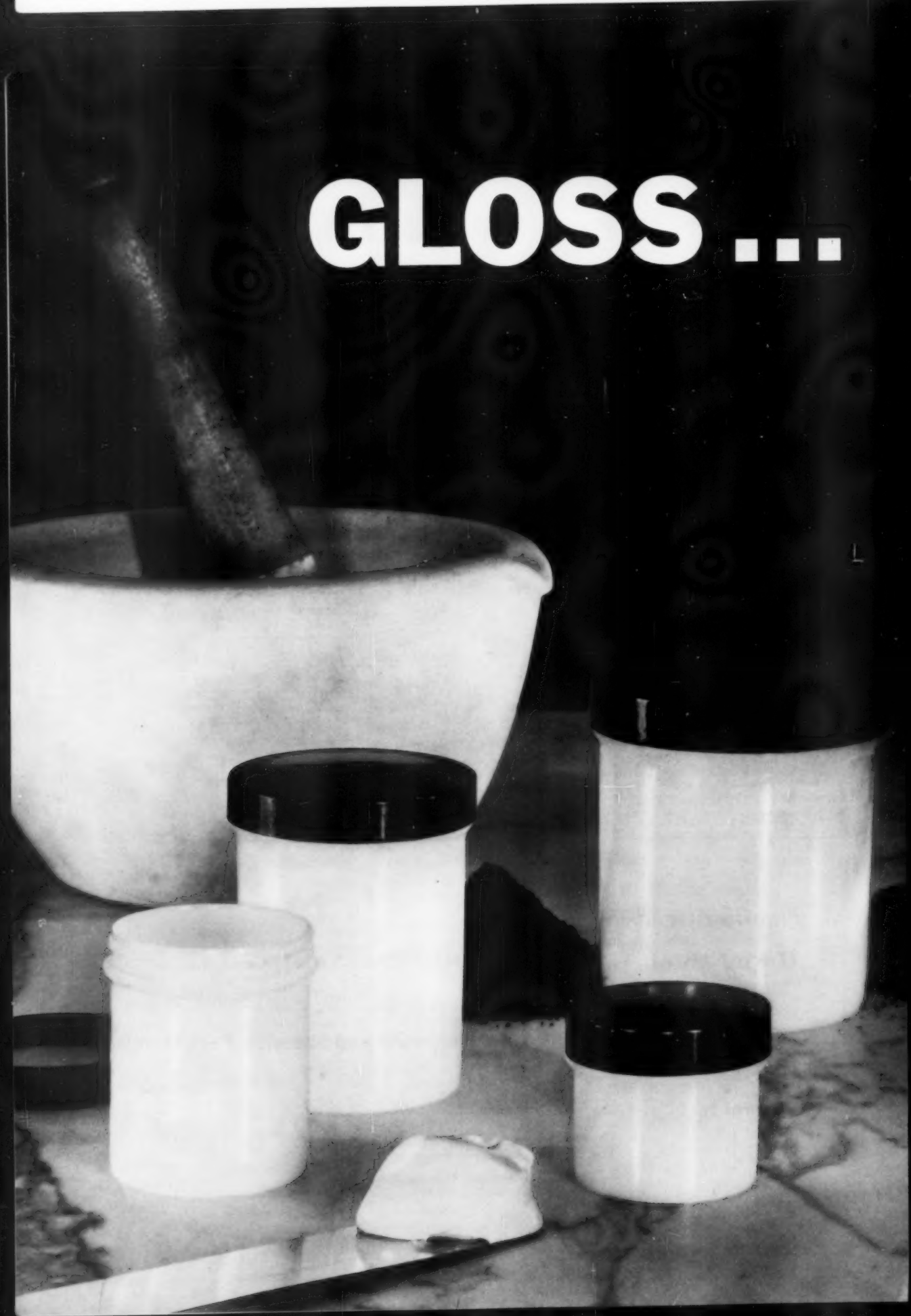
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TYPICAL PROPERTIES OF DMD-7000

Properties	ASTM Test	Typical Value
Density, gm/cc	D 792	0.96
Melt Index, gm/10 min.	D 1238	5.0
No-Load Heat Distortion Temperature*		130°C. (266°F.)
Secant Modulus (stiffness), psi	D 638	150,000
Tensile strength, psi	D 638	4600
Ultimate Elongation, %	D 638	15
Durometer Hardness "D"	D 1484	65

*Obtained on injection molded specimens

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DOW Plastiatrics
DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

CALCULATING CREEP AND STRESS RELAXATION FROM LONG-TERM DATA

For design engineers concerned with calculating the effects of stress and strain on plastics materials, particularly in designing for long-term applications, the Equations of State (Fig. 1) permit good approximations, to which, of course, will be added a reasonable safety factor.

Obviously, long-term strength data must be used in the equations, since short-term or elastic data do not correlate with long-term service. For example, in designing plastic lawnmower wheels, data obtained over a five-year period would normally be used because this period of time corresponds to a reasonable service life for this type of part. Below are examples of calculating stress, strain and the modulus of elasticity, using long-term data from Fig. 2. These are simple situations. Often shock, high temperatures or other environmental factors must also be taken into consideration.

Example I: A tensile stress of 1000 psi will be applied to a part made of Tyril 767. How much creep will occur during the first six months (4320 hours)? From Fig. 2, the Apparent Modulus at six months is 420,000 psi. Using Equation 2a (Tension):

$$E=\frac{S}{\epsilon} \text{ and } \epsilon=\frac{S}{E}. \text{ Then } \epsilon=\frac{1,000}{420,000}=0.0024, \text{ or } 0.24\% \text{ elongation.}$$

Example II: Where a known strain is placed on a part, such as a bottle closure, calculate the remaining stress (resistance) after one year. Assume the strain to be 0.42%. Apparent Modulus of Tyril 767 after one year is 380,000 psi.

$$S=E\,\epsilon=(380{,}000)\,(0.0042)=1590 \text{ psi remaining.}$$

Example III: Creep is important in designing webbing and cloth from plastic monofilament. From Fig. 2, Apparent Modulus of Dow saran monofilament after 1½ years is 70,500 psi. Under a stress of 1000 psi, creep is then:

$$\epsilon=\frac{S}{E}=\frac{1000}{70{,}500}=0.0142 \text{ in./inch, or } 1.42\% \text{ elongation.}$$

Example IV: In a hypothetical filter sump for a home water system, the filter must last five years, and operate at a maximum internal pressure of 75 psi. To insure a sufficient O-ring seal, total radial deformation of the sump must be less than 0.007 in., to prevent leakage. Tyril 767 has good long-term strength, ease of fabrication and low cost. Will it be satisfactory for this use? The design strength of Tyril 767 is 980 psi (from Fig. 2) over a period of five years (43,800 hours). From the following formula, solve for "P" (maximum allowable operating pressure).

$$P=\frac{S\left[r^2(b^2-a^2)\right]}{a^2(b^2+r^2)}=120 \text{ psi.}$$

Where: a = Inner radius = 2.05 in.
b = Outer radius = 2.30 in.
r = Normal radius = 2.175 in.
v = Poisson's Ratio = 0.035
Δa = Change of inner radius, in.
S = (design) Hoop Stress, psi
P = (maximum allowable operating) Pressure, psi.

Thus, the maximum allowable operating pressure for Tyril 767 is well above the operational maximum encountered in the water system. To determine total radial change of the O-ring:

$$\Delta a=P\frac{a}{E}\left[\frac{b^2+a^2}{b^2-a^2}-v\left(\frac{a^2}{b^2-a^2}\right)-1\right]=0.00225 \text{ inch.}$$

Not only is the five-year design strength of Tyril 767 adequate for this application, but it provides a safety factor of 1.6 for operating pressure, and of 3 for the O-ring seal.

Many long-term data of the type used in the examples above, are being developed by Dow Plastics Technical Service Engineers for use by plastics engineers and designers. Such continuing Plastiatrics studies provide not only properties data, but also information on improved methods of design, molding and finishing of plastics. For more detailed information on these studies, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Dept. 1801EX7.

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EQUATIONS OF STATE

1. To calculate simple stresses
   (a) Stress in Tension: or in Compression
   $S=\frac{P}{A}$ P = Applied load; A = Cross-sectional area of the part
   (b) Stress in Flexure (rectangular beam)
   (A) Simple support, center loading
   $S=\frac{3PL}{2bd^2}$ P = Applied load; L = Distance between supports; b = Width of beam; d = Depth of beam
   (B) Simple support, uniform loading
   $S=\frac{3PL}{4bd^2}$
   (C) Cantilever beam, end loading
   $S\text{ max.}=\frac{6PL}{bd^2}$ P = Applied load; L = Distance from load to support; b = Width of beam; d = Depth of beam
   (D) Cantilever beam, uniform loading
   $S\text{ max.}=\frac{3PL}{bd^2}$
2. To calculate modulus of elasticity in the above examples.
   (a) Modulus in Tension; or in Compression
   $E=\frac{S}{\epsilon}$ S = Stress; ε = Strain
   (b) Modulus in flexure
   (A) Simple support, center loading
   $E=\frac{L^3m}{4bd^3}$ m = initial slope of flexure curve
   (B) Simple support, uniform loading
   $E=\frac{5L^3m}{32bd^3}$
   (C) Cantilever beam, end loading
   $E=\frac{4L^3m}{bd^3}$
   (D) Cantilever beam, uniform loading
   $E=\frac{3L^3m}{2bd^3}$

FIG. 1

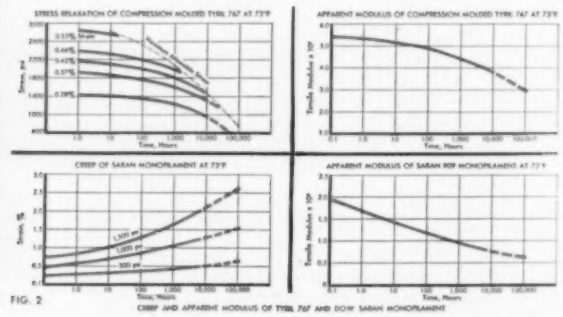

STRESS RELAXATION OF COMPRESSION MOLDED TYRIL 767 AT 73°F
APPARENT MODULUS OF COMPRESSION MOLDED TYRIL 767 AT 73°F
CREEP OF SARAN MONOFILAMENT AT 73°F
APPARENT MODULUS OF SARAN 909 MONOFILAMENT AT 73°F
Time, Hours

FIG. 2 CREEP AND APPARENT MODULUS OF TYRIL 767 AND DOW SARAN MONOFILAMENT

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

SOCIETY ACTION

New Manual to Guide Section Operation

G. Palmer Humphrey

Chairman, SPE Sections Committee

(R. C. Molding Incorporated)

This month Officers and Board members of all SPE Sections will receive copies of SPE's new "Sections Manual of Procedures". The Manual will make available for the first time the successful procedures and know-how that have been developed over the years by SPE Sections and by sections of related engineering societies. It is the culmination of years of effort by SPE members from many Sections. SPE Council expressed its appreciation to them at its meeting in Cleveland on May 16 by unanimously adopting the Manual with special commendation to the SPE members in Sections, on the Sections Committee, and on the Executive Office Staff, who made it possible by their contributions.

In 1958, Council recognized that the rapid growth of the Society and its Sections had created an urgent need for a Committee and a Manual to assist and guide Sections by establishing and publishing uniform policies of organization and operation and by improving communications between the Society and its Sections and among all Sections. As a result, with the adoption of SPE's revised Constitution and By-Laws in February, 1959, the SPE Sections Committee was authorized and came into being. Its first assignment was to compile and publish a Manual of Procedures to assist Section Officers and Committeemen to organize and operate their Sections effectively and in concert with all other Sections.

Incorporated in the Manual are the best of the Section policies and procedures established by Council since the Society was founded.

As with other SPE procedures manuals, it is expected that some revision will be required from time to time to meet changing conditions. In such cases, revised pages will be mailed to replace obsolete pages in the loose-leaf manual.

In the conviction that maximum autonomy of Sections must be maintained within the framework of the Constitution and By-Laws, rules and regulations have been limited to those required to obtain uniformity and continuity, particularly with respect to finances, elections, and appointments.

One of the most important rules incorporated in the Manual is the one on Section election dates which was changed by majority vote of Council (and also of Sections) at its May 16, 1960, meeting, from the calendar-year to fiscal-year basis. The new rule now reads:

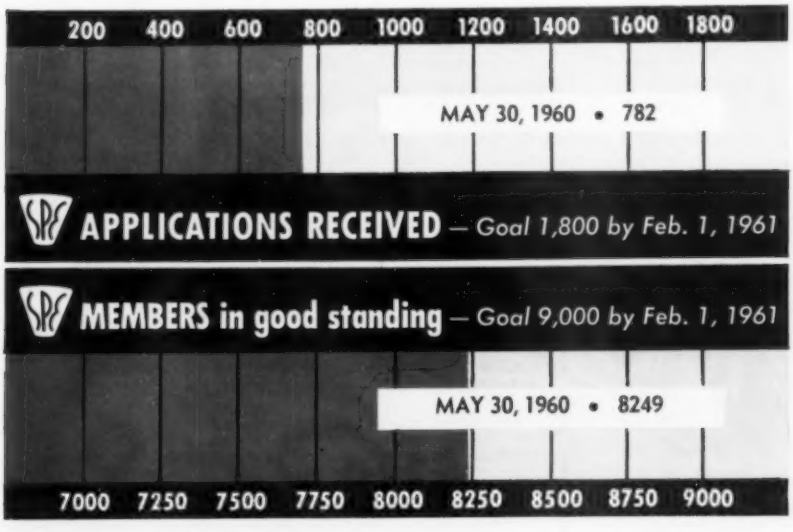
> All Section Directors shall be elected in April to take office on July 1 (fiscal-year basis) and all Section Officers shall be elected from the outgoing Board of Directors at a May Board Meeting, also to take office on July 1.

So that Sections previously electing Officers and Board members on a calendar-year basis can effect a smooth and uniform transition, it was ruled that Officers and Board members who assumed office on January 1, 1960, shall hold office for 1½ years until June 30, 1961.

Your Sections Committee believes that a careful review of this Manual and acceptance of its guidance by your Section Officers and Board members will pay big dividends. It will increase your efficiency and thereby make your jobs easier and more beneficial to your Section members.

Suggestions for improvement of this Manual are not only welcome but are solicited by our Committee. Since we realize that your suggestions provide the best possible means of maintaining the Manual as an up-to-date working tool, careful consideration is assured.

Please address your ideas to the Chairman, SPE Sections Committee.



edited by **Thomas A. Bissell**

SPE Executive Secretary

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by **Louis B. Allen,**
Chairman, Standards for Reporting Plastics Properties PAG

PAG Progress

Standards For Reporting Plastics Properties PAG Program

This group was organized to fill a need in the plastics field—uniformity in reporting basic raw material standards. This need in other fields resulted in the formation of ASA, ASTM, and joint military standards for electronic components, among others. It is a need which is immediately obvious to designers and quality control people.

Anyone faced with the problem of a material choice, and subsequently a vendor choice, is immediately faced with a complex decision, if his application makes serious demands on the properties of a material. In order to make the best decision he must correlate physical data on the same class of materials from several manufacturers. If he is interested in impact strength, he finds that some companies report on notched samples, some on un-notched, some on both; some on Izod, some on Charpy, some on both. Some even use tensile-impact methods. If he is interested in tensile elongation he finds that one company used a 2" per minute cross head speed and another, 0.2" per minute cross head speed. Similar variations are noted in other test methods. It has been observed that non-standard tests are used and sometimes a unique test is used by a company which will show up the virtues peculiar only to his material. More important are the variations used to report the property values obtained. Some manufacturers use arithmetic or algebraic average. Others use the minimum, the average minimum, a guaranteed minimum, an arbitrary value below the average, an arbitrary value below the minimum, and in some cases, values above the average. Imposed on all this confusion is the variation caused by sampling procedures, molding techniques, and sample sizes used.

All of this is within the realm of reasonable ethics and is common when a new industry shows rapid growth. However, the plastics industry is now a mature one. Large numbers of designers, mechanical engineers and materials engineers are becoming familiar with the multitude of uses for these materials. It is time that they had available a background of physical and mechanical property data which are meaningful enough to permit useful comparisons between materials.

It is the function of this group to draft a standard form for reporting of raw material properties and to forcibly recommend industry-wide acceptance of this form. It is intended that ASTM methods be used where possible.

History

The initial suggestion out of which this group arose was made by R. J. Hill, of Boonton Company in April, 1958. A petition was prepared and submitted to Council. In September, 1958 the Group was given official acceptance. However, the actual organization was not accomplished until January, 1960. At this time, officers and task group chairmen were appointed. The initial goal of listing pertinent tests in each category was completed. These lists will be gone over in great detail among the various task groups for inclusion in the final form.

Present Officers (1960)

Chairman: Louis B. Allen, IBM Corporation, Endicott, New York
Vice Chairman: Kenneth A. Erwin, Marbon Chemical Co., Washington, West Virginia
Secretary: Louis L. Lander, Union Carbide Plastics Company, Bound Brook, New Jersey

Task Group Chairmen

1. *Analytical Properties*— Louis B. Allen, IBM Corporation, Endicott, New York
2. *Thermal Properties*—H. R. Larsen, Carbide Chemicals Company, Montreal, Quebec
3. *Optical Properties*—E. N. Robertson, Rohm & Haas Company, Philadelphia, Pennsylvania
4. *Mechanical Properties*—David P. Norris, Union Carbide Plastics Company, Bound Brook, New Jersey
5. *Permanence Properties*—G. H. Williams, Bell Telephone Laboratories, Murray Hill, New Jersey

The response to the projected activity of this group has been heartening. However, there is room for improvement. It is extremely important for the success of this Group to have an interested, enthusiastic, hard working membership. Why not extend your enthusiasm to encompass the PAG of your choice?

—— ■ ——

edited by
Frank W. Reynolds, *PAG Administrator*
(International Business Machines, Inc.)

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This month's column has been made possible through the contributions of these abstracters:
Dr. Albert Lightbody (Australian Plastics and Rubber Journal)
Evert A. Mol (British Plastics)
Alexander Baczewski (L'Officiel des Matières Plastiques)
R. George Hochschild (Pensez Plastiques)
Hans Mayer (Industrie Des Plastiques Modernes)
Alfred L. Alk (Materie Plastiche)
Leonard S. Buchoff (Materials in Design Engineering)

PLASTICS AROUND THE WORLD

Australia

AUSTRALIAN PLASTICS AND RUBBER JOURNAL

JANUARY 1960

Associations Between Australian and Overseas Manufacturers Organizations—pp. 25-26.

760 Australian Companies have licensing agreements with United States organizations. The government of New South Wales, Australia, has recognized the advantages of effective representation in the U. S. A. and has established an office in New York under the control of a commissioner, Dr. A. Denning. This office will assist Australian manufacturers who are interested in arranging licensing or business affiliations with firms in the U. S. A.

England

BRITISH PLASTICS

MARCH-APRIL 1960

Injection Molding of High Density Polyethene—March, pp. 100-104, April, 154-158

The thermal properties of high density polyethylene make special precautions in molding design and press operation necessary. It is very important to keep the stock temperature as uniform as possible, high density polyethylene is very prone to distortion due to internal strains. The use of a preplasticizing machine is recommended and surface temperatures in the mold must be carefully controlled by special design cooling passages. Normal injection temperatures range from 200-250°C. for a melt index of 5.0 to 250-280°C. for a melt index of 1.5. Long injection times should be avoided. They may result in packing and internal strains. The rate of cooling has a pronounced effect on the final crystallinity. Thus strict mold temperature control is essential. Other subjects discussed were mold shrinkage, surface finish, dry coloring, gate brittleness, and distortion. Gate brittleness can be overcome by temperature control of the sprue area, starved feed techniques, and correct design of the base of the article.

France

L'OFFICIEL DES MATERIES PLASTIQUES

APRIL 1960

Non-Supported Films—pp. 297-301

Various procedures for the manufacturers of films consisting of regenerated cellulose or of alginic acid are given. 32 patent references.

Shaping of Hollow Articles—pp. 303-307

Plastic sheets can be formed by heat and pressure, lattices yield bottles and the like by dipping, PVA solution and cuprammonium cellulose are coagulated on molds. 59 references.

Problem of Industrial Hygiene—pp.313-317

The inhalation of dust or of breakdown products of many plastics is sometimes only obnoxious but very often it may be extremely dangerous, Poly(tetrafluoro)ethylene e.g. when heated, causes grave pulmonary irritations. Several monomers are systemic poisons, most of all acrylonitril and styrene. Vinyl chloride though is comparatively harmless. Dermatitis is caused often by polyesters and epoxy resins. General suggestions as to improved hygiene follow. The author points out that some persons might be sensitive to chemicals exuding from rubber gloves or contained in protective hand creams.

INDUSTRIE DES PLASTIQUES MODERNES

MARCH 1960

Polyvinyl Acetates

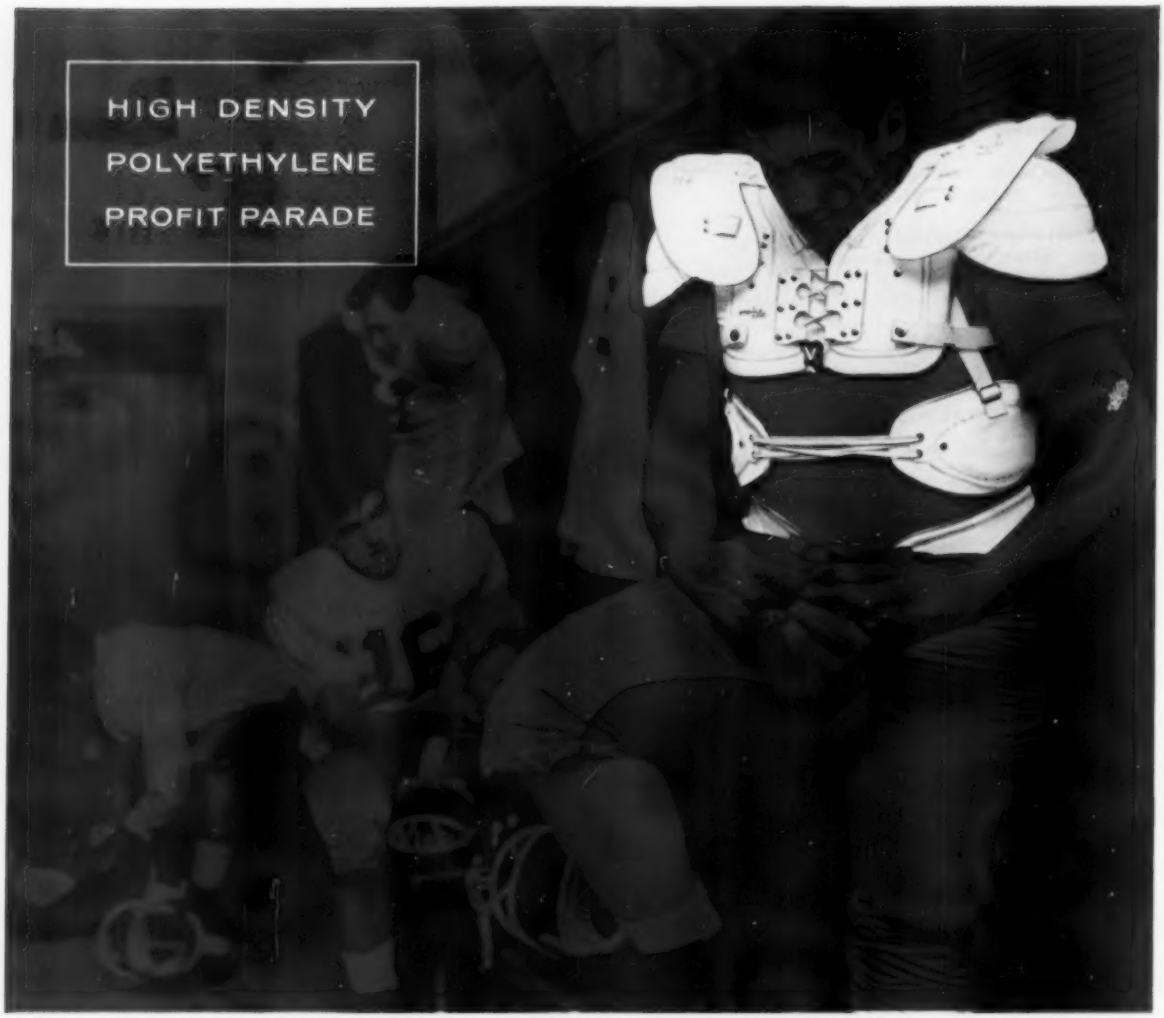
This issue is dedicated to the field of Polyvinylacetates. The general introduction describes the manufacturing methods for polyvinylacetate at the factories of Hoechst Farbenwerke in Germany. The use of their dispersions (trademarked Movilith) through the paint industry is described by Dr. August Schaefer, possible and advantageous applications in the building industry are presented by Dr. Joachim Ebigt, and Dr. Peter Jeckel suggests a variety of industrial uses for this type of material, mainly along the line of insulation and protection. A new development is a method of molding shock resistant articles by using fibers, impregnated with polyvinyl acetate as the molding material.

PENSEZ PLASTIQUES

JANUARY 1960

The Ko-Malaxeur in the Plastic Industry—pp. 17-20

This is a review of a novel type of extruder which has been developed during the past ten years. Its principle consists of a screw with lands which are sectioned into three sections, with an open space between each land section. Each of the open spaces or voids is positioned in such a way that it corresponds to a tooth in the barrel. These teeth mesh with the lands rather loosely to allow passage of the plastic mass between the voids and the teeth of the barrel. Contrary to the normal rotary movement of an extruder screw, the screw of the Ko-Malaxeur also moves in a back-and-forth fashion. Thus when the machine is in operation, each land retreats to the center of the preceding flight



Sheet From Grace Plastic Improves Protective Equipment

The 1960 football season will see a major improvement in protective equipment, resulting from the combined ideas of the Panelyte Division of St. Regis Paper Company and Rawlings Sporting Goods Company. Panelyte, a leading extruder of thermoplastic sheet, recognized the selling advantage which could be obtained by improving the impact strength, among other properties, of plastic sheet by using Grex high density polyethylene. Rawlings, a customer of Panelyte, was quick to take advantage of these properties by using sheet made from Grex to improve their protective football equipment. The end result is the Crusader brand shoulder, hip and rib cushions now being introduced by Rawlings.

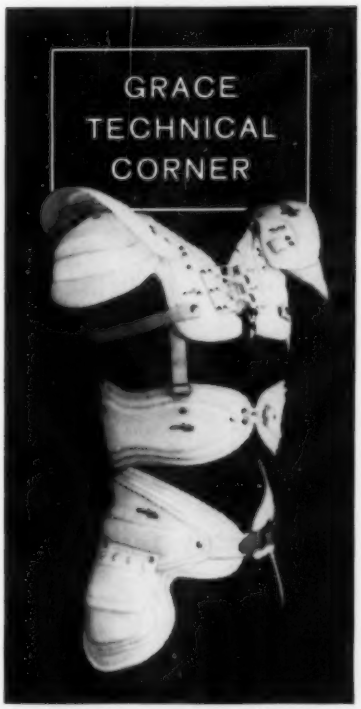
The parts of this redesigned protective equipment are many times stronger than the fiber used in conventional equipment. They are flexible enough to provide increased shock absorption and better body fit. They show less splitting or cracking than fiber, are impervious to perspiration and are unaffected by temperature changes.

Product advantages such as these—made possible through the use of high density polyethylene—are paying off for both Rawlings and Panelyte. Advantages of your product using this Grace plastic could be equally profitable.

Find out exactly what high density polyethylene offers for products in your field by calling in the experts. Grace has the production facilities, technical service and experience to help put your new product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY



Football protective equipment demonstrates rigidity and impact strength of Grex

How strong is Grex high density polyethylene? According to the notched Izod test its impact strength ranges from 1 to 12 ft.-lb. per inch notch, depending on resin grade. A more practical way to assess the strength and rigidity of Grex is to look at products made of this plastic. Rawlings football protective equipment is one good example. Shoulder, rib and hip cushions are subjected to extremely rugged conditions of use. Where other suitably rigid materials crack, split, shatter or break on impact the new Grex parts are unaffected. There are many other equally dramatic examples.

Milk delivery cases. New cases molded of Grex stand up under rough treatment in the dairy and along the delivery route. Furthermore, they do not become brittle even at temperatures as low as −160° F.

Boat bumpers. Boat bumpers made of Grex provide all the strength necessary to withstand repeated impact and abrasion at the landing dock. In addition, they are unaffected by salt water.

Shipping containers. Banana boxes as well as potato chip shippers are made of Grex. In both cases, rigidity and impact strength are essential for protecting easily damaged foodstuffs. Increased trippage and reduction in product loss make these competitive in cost with conventional containers.

Other examples. Safety helmets, fishing tackle boxes, tote boxes for in-plant use, lids for garbage cans and caps for gas cylinders are all made of Grex to obtain the strength and rigidity needed. How about the product you currently have in the works? If you believe it is an application for Grex, now's the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, New Jersey

and then, in turning, advances to the center of the next space between the teeth of the barrel. Thus, the rotary movement is combined with a rocking, oscillating type motion.

Several different types of Ko-Malaxeur are described, with their respective advantages and uses in special applications, such as compounding, extrusion and post-calendering.

APRIL 1960

Polyethylene Molding Materials—pp. 3-9

A thorough review on the effects of molding conditions on the properties of Union Carbide types DYNF, DYNH, DYNJ and DND-0400 polyethylene. Items discussed are stock temperature, injection pressure, mold temperature and molding techniques. Molding conditions are recommended to achieve a number of desired effects. Several tables and graphs illustrate the most important points.

Evaluation of Polyethylene Wrappers to Protect Growing Fruits—pp. 21-28

The excellent article discusses the use of polyethylene as a protective wrapper for fruit growing on trees and bushes. A statistical analysis on the weight of paper-wrapped versus polyethylene-wrapped fruit is given, together with comparisons on the ease of wrapping with paper versus polyethylene, the number of drops, the types of insect attacks, and the rates of growth. Three mil polyethylene was used throughout the study which was conducted during several growing seasons. The article is taken from a comprehensive report given at the International Horticultural Congress of 1958.

Italy

MATERIE PLASTICHE

MARCH 1960

The Use of Laminates of Polyester Reinforced with Glass Fibers in the Construction of Greenhouses—pp. 210-218

Experimental work has been done to promote the employment of polyester-glass panels, both flat and corrugated, in greenhouse glazing. The advantages of laminate over glass include toughness, lesser weight, low modulus of elasticity allowing movement of supporting frame, and ease of application. The quality of illumination is stated to be better than under glass because the intensity of light is lowered with a lessening of foliage burning, and because the material is less transparent to wave lengths of light which have no, or less effect on plant growth. It is claimed that the insulating value of the laminate results in lower heat losses amounting to as much as 3°-4°C over glass. Test plantings of various market crops showed higher yields, faster maturing and less plant loss. Illustrations demonstrate the light weight construction adequate for support.

Evaluating the Workability of PVC in the Presence of Plasticizers—pp. 219-222

The principal factors influencing the workability of PVC in the presence of plasticizers are discussed. Micro-photographs illustrate points made in the text. Routine test procedures are outlined for determining characteristics of samples. The different physical properties of suspension and emulsion polymers are explored. The constitution of fish eyes or gel particles is examined and methods discussed for their elimination in production.

Working Thermoplastic High Polymers in Twin Screw Extruders with an Extended Single Screw—pp. 223-229

The author discusses the problem of properly fluxing granulated thermoplastics given the physical facts that as the particle melts, the elastic or fluid mass surrounding the core tends to insulate it from further heating and to protect it from mechanical action because of the lower viscosity and lubricity of the melt. The introduction of screens and perforated plates breaks up the cores but allows small unfused or unsolvated particles to be extruded. To bring viscosities of melt and cores to equal values the temperature of the mass may be altered by cooling, thereby cancelling the protective effect of the melt, increasing the shear and the pressure. The effects vary with the location of the cooling. Output is usually decreased in single screw extruders. In twin screw extruders, output remains constant but the increased shear increases the temperature of the mass uncontrollably and limits production to thin sections. By

Plastics Around the World —*Continued*

doubling the length of one of the twin screws, the objections are overcome. Fusion and homogeneity are obtained in the twin section at constant output regardless of the pressure or viscosity, and the temperature can be lowered in the single screw section.

Experiments performed with such an extruder are described. Photographs of the twin screws extracted when full of material brilliantly illustrate the text.

The Copolymers of Vinyl Chloride —pp. 236-242

Part VI: Copolymers with unsaturated polycarboxylic acids and their derivatives. Continuation of a series. This section covers copolymers with maleic, fumaric, itaconic, aconitic acids and their esters. Particularly important among these are the tri-polymers containing small amounts of free maleic acid which are liberally used in primers and adhesives, and the co-polymers with maleic diesters. The article contains tables, graphs and 46 references.

The Sterilization of Plastics—pp. 259-270

Sterilization may be achieved by the following methods: physical: dry heat, moist heat, ultraviolet rays, infra-red rays, filtration and pressure; chemical: gaseous vapors, chemical products antiseptics and radiational energy. The article describes plastics currently being subjected to sterilization by these methods. Some effects of sterilization on the various plastics are mentioned, and there are many illustrations. 45 references in the bibliography.

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MATERIALS IN DESIGN ENGINEERING

FEBRUARY 1960

Low Pressure Reinforced Plastics

The high strength to weight ratio, plus the ability to be easily formed into complex curvatures are among the most important reasons for the extensive use of low pressure reinforced plastics in structural applications. Reinforcements include fibrous glass, asbestos, nylon, Orlon, Dacron and Dynel. Recently graphite textiles have appeared. Polyester resins are used because of the low cost, excellent process characteristics and good balance of properties. Triallyl Cyanurate polyesters are used at high temperatures. Epoxies are used in reinforced plastics because of their excellent mechanical strength, low moisture absorption and excellent electrical properties. Heat resistant applications call for phenolics. Silicones are used where high heat resistance in combination with excellent electrical properties are required. Acrylic syrup is used in applications where weather resistance is critical.

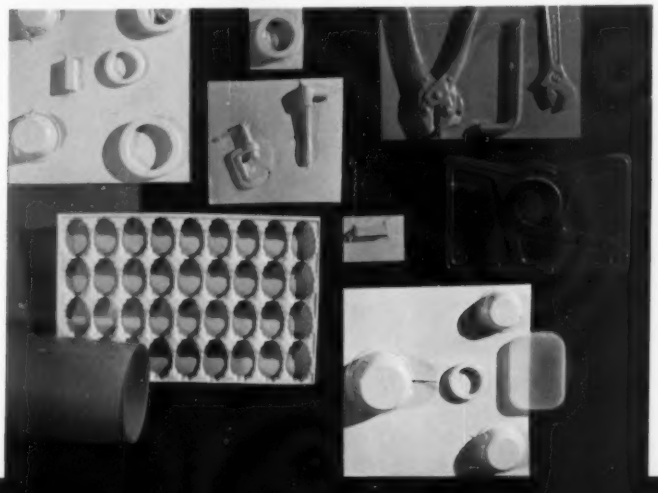
Short time mechanical strength and effects of duration of loading are presented. The effects of cold and heat, electrical properties, and the effects of chemicals and weather are presented very well.

Fluidized Bed

This excellent article describes the fluidized bed process, advantages and applications. The mechanical, electrical, thermal and chemical properties of Cellulosics, vinyls, epoxy, nylon, polyethylene, chlorinated polyether coatings are given.

Finding the right vinyl . . . does it with research in depth.

Pinpointing application does it on production-scale equipment.



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NOTE THESE ARTICLES OF INTEREST IN THE JULY ISSUE OF MODERN PLASTICS

PRE-PREGS – Out of the range of the missile and aircraft programs comes a new range of materials with tailor-made muscles. The pre-preg industries have, in the past, been faced by the problem of standard uniformity. This article examines this obstacle and provides a progress report on efforts towards a solution.

TEN PREDICTIONS FOR THE '60s. A look into the future by an authority on plastics management and marketing, outlining the status of the industry in the years to come–an invaluable guide to those concerned with the planning.

WHAT PLASTIC IS IT? Gatefold chart gives step-by-step procedures for identifying thermoplastic and thermoset materials. With growth in the number of commercial resins, identification is no longer a simple matter. However, the tests here presented are far from complicated.

POLYCARBONATES ARE STARTING TO MOVE. With over 200 commercial applications developed before full commercial resin production was announced, the industry anticipates a healthy growth for this new material. Here is an outline of the markets, production prospects, applications and processing requirements.

EXTRUDING POLYPROPYLENE FILM. The extrusion of polypropylene film can be accomplished by either the chill-roll, or water-bath process. The former gives a better balance of strength properties, while the latter produces higher stiffness and gloss. Here, the effects of water bath temperature and air gap are fully analyzed.

POLYMERIC MELTS. This is a report on the steady-state flow-properties of molded polymers and the effect of pressure on these polymers.

Plus many other interesting "applications" stories.

COMING IN AUGUST:

FILM LAMINATIONS. Article tells what's available and what they can do. Table will list the most commonly used types.

WHEN AND HOW TO USE PRESSURE FORMING. Modification of the thermo-forming process shows great potential in the packaging field.

D.A.P. New competitor in the decorative laminates field, diallyl-phthalate laminating resin offers new economies to furniture manufacturers. Case histories spell it out in detail.

THE ENCYCLOPEDIA ISSUE

The 1200-plus page MODERN PLASTICS ENCYCLOPEDIA ISSUE published in September of each year furnishes subscribers with a wealth of valuable working information...through its articles, Buyer's Directory, charts, diagrams and tables. The Encyclopedia is the most inclusive, most authoritative reference work on plastics available.

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SECTION NEWS

Chicago

Plastics in the Home

May meeting for the Chicago Section was Ladies' Night. Speaker was T. J. Martin, Coordinator, Customer Relations Dept., Monsanto Chemical Co. The talk covered new plastic applications for home building and furnishings.

Connecticut

New Thermoplastic Subject of Talk

K. G. Clarke

The May meeting of the Connecticut Chapter of the SPE was held at the Hotel Barnum in Bridgeport on May 13; guest speaker of the evening was Mr. John Y. Lomax, Plastics Sales Development, Hercules Powder Company. A new thermoplastic, Penton, was the subject of Mr. Lomax's talk.

Penton is a thermoplastic having unusually high resistance to chemicals, service temperature, and creep. The outstanding stability of this material is attributed to the lack of hydrogen in position beta to the chlorine present in the molecule.

In applications involving corrosion resistance and high temperature, it is surpassed only by Kel-F and "Teflon", according to Mr. Lomax. The majority of the applications for this remarkable material to date have been in the field of chemical process equipment: valves, gaskets, piping, meter components.

Indianapolis

The Field of Plastisols

D. E. Collins

The Central Indiana Section conducted its regular monthly dinner-business meeting at the Continental Hotel, Indianapolis, May 24th. The speaker, Mr. William LeMay of Ohio Sealer and Chemical Company presented his subject "The Field of Plastisols" very thoroughly.

Plastisols are mixtures of resins and plasticizers which can be molded, cast, or converted to continuous films by application of heat. If the mixtures contain volatile thinners also, they are known as Organosols.

Because of this liquid to solid conversion without the need for pressure, plastisols are adaptable to simple, economical molding by a wide variety of methods. They may be formulated to have varied physical and chemical properties. Some of the properties include: tensile strength, elongation, hardness, low temperature, flexibility, heat and acid resistant, impact strength and color.

Type of molding included: Dip, slush, rotational cast, injection and some extrusion work. Potential fields for plastisols cited were vinyl coated steel, decorative panels, vinyl foams, etc. Vinyls along with polyethylene surpassed the billion pound mark in 1959. The resins are forecasted at the two billion pound level by 1965.

Central New York

Compression Molding of Thermoplastics

Mr. John Meyer introduced the speaker, Mr. Stephen Kalarian of Haveg Industries. Mr. Kalarian's subject was "Some Aspects on Compression Moulding of Thermoplastics". He stated that compression moulding was the work-horse of the industry. This method is economical, allows material interchangeability, reduces presence of weld lines and stresses. Moulds are cored to accommodate thermal heaters. 500 psi is used on warm material in the first press before transfer to the final press for complete fusion of the material. Normal steels are used for the moulds, i.e. SAE3312. Compression moulding of thermoplastics is best for thick moulded sections. It also allows any thermoplastic material to be moulded in the same mould. These are hand-type moulds and runs are small, in the range of up to 5000 pieces per year.

Florida

Acrylic Molding Powders

Jack Grosscup

Mr. Jack Spencer of Technical Sales Division of the Rohm & Haas Company, Philadelphia spoke to the Florida Section at their May 18th meeting on the four varieties of R & H "Implex", a modified acrylic molding powder.

The molding compound is currently available in formulas A, B, C & F. "A" is the most flexible and has the highest impact strength. "B" has better moldability and better gloss

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Plasticizer	Specific Gravity 25°/25°C ±.003	Viscosity 25°C, cps	Compatible With	Outstanding Characteristics
Dibenzyl Sebacate	1.055	21-22	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers.	Low Temp. Flexibility, Low Volatility, Permanence. Good Electricals
Dibutyl Sebacate	0.935	7.9	Vinyl Resins, Cellulose Acetobutyrate, Synthetic Rubbers, Rubber Hydrochloride, Polystyrene, Polymethyl Methacrylate.	Low Temp. Flexibility, Excellent Aging Qualities, Non-toxic
Dimethyl Sebacate	0.986°	3.54 @ 30°C	Vinyl Resins, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate, Acrylic Resins.	High Solvency and Efficiency, Wide Compatibility
Dioctyl Sebacate	0.913	17.4	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility, Low Volatility, Good Electricals
Dicapryl Phthalate	0.972	55	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Highly Compatible, Low Volatility, Excellent Viscosity and Stability
Diisodecyl Phthalate	0.965	65	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Cellulose Nitrate, Cellulose Acetobutyrate, Chlorinated Rubbers.	Low Volatility, Good Electricals
Dioctyl Phthalate	0.983	57	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Highly Compatible, Good Flexibility
Isooctyldecyl Phthalate	0.973	68	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetals, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Improved Flexibility, Permanence, Good Electricals
Dioctyl Adipate	0.924	21	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Natural and Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate.	Low Temp. Flexibility
Butyl Stearate CP	0.857/0.86	9.1	Natural and Synthetic Rubbers, Cellulose Esters, Polystyrene, Polyvinyl Butyral: partly compatible with Polyvinyl Chloride and Nitro Cellulose.	Lubricity, Abrasion Resistance, Low Cost, Non-Toxic
Butyl Oleate, distilled	.8685/.869 @ 20/20°C	7.2	Most Natural and Synthetic Rubbers, Polystyrene, Cellulose Nitrate, Ethyl Cellulose.	Low Temperature Flexibility, Primary Plasticizer for Chloroprene, low cost
®Harflex 300	1.096	1400 @ 100°F/cs	Polyvinyl Acetate, Cellulose Acetobutyrate, Nitrocellulose, Ethylcellulose, Polymethyl Methacrylate.	Non-Migratory, Fast Processing Low Temp. Flexibility
®Harflex 325	1.100	2000 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Polyvinyl Acetate, Synthetic Rubbers, Nitrocellulose, Cellulose, Acetobutyrate, Polymethyl Methacrylate.	Non-Migratory, Permanent
®Harflex 330	1.081	2270 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Synthetic Rubbers, Nitrocellulose, Cellulose Acetobutyrate.	Non-Migratory, Permanence, Highly Compatible
®Harflex 375	1.016 ° 30°/20°C	45000 @ 100°F/cs	Vinyl Chloride Polymers and Copolymers, Nitrocellulose, Synthetic Rubbers.	Extreme Permanence

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than "A". "F" is essentially the same as "B" except for its heat distortion temperature. "F" was developed mainly for the vending machine industry and has National Sanitary Foundation and Beverage Manufacturers approval.

Mr. Spencer presented samples of typical uses, some of which were: beverage dispenser housings, outboard motor housings, automobile dashboard clusters, salad bowls, swimming pool equipment, typewriter keys, piano keys, electric razor housings, shoe heels, control knobs, sprinkler heads and pipe fittings.

After Mr. Spencer's talk, Al Greenblatt, membership chairman, reported that the Florida Section is in third place in the national membership drive.

Perry Jeanes, sales technologist, with E. I. duPont de Nemours, Philadelphia, spoke to the group on DELRIN, duPont's new acetal resin at the Section's meeting in April.

Milwaukee

Plastisols

C. H. Strong

Guest speaker of the evening was Mr. James B. Hull, President of the Hull Development Corporation, Consultant Engineers. Mr. Hull talked about the plastic of the future and called it Shawnol, which is classified as a plastisol. He gave a complete definition of plastisols, along with the description of how to manufacture them. He described and had illustrations along with numerous demonstrations, of Shawnol's use in dipping, spray coating, casting, solid casting, low pressure injection molding, slush casting, rotational casting, spread coating, and extrusion.

Mr. Harold Hultz, of the National Membership Committee, was a guest at the meeting.

Ontario

Plastics in the Boat Industry

Harold A. Shure

There were at least 130 people at the May meeting of the Ontario Section in Toronto, when "Plastics in the Boat Industry" was discussed under the following subjects by the panel, under the chairmanship of M. A. Zarebski.

1) Future Forms and Designs of Reinforced Boats.

M. A. Zarebski
Manager Reinforced Plastics
Reichhold Chemicals (Canada) Ltd.

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2) How to buy a Reinforced Plastic Boat.

Sid Nicholes
Sales Manager
Bay Mills Limited

3) Market Statistics.

James T. James
Sales Manager
Barry Glass Industries Limited

4) Marketing of Reinforced Plastics Boats.

Jim Bryden
Manager of Alkyds & Plastics Dept.
Canadian Pittsburgh Industries Ltd.

5) Plastics Foam in Boat Construction.

James C. E. Fuller
Sales Manager Plastics
Naugatuck Chemicals
Div. of Dominion Rubber
Company Ltd.

6) New Methods of Production.

Ed Newman
General Manager
Product Techniques & Supply Ltd.

7) Need for Public Education Program.

Wally Cannon
Manager of Plastics & Oxide Div.,
Ferro Enamels (Canada) Ltd.

8) The Future of the Reinforced Plastics Boat Industry.

M. A. Zarebski
Manager of Reinforced Plastics
Reichhold Chemicals (Canada) Ltd.

Registered in Canada, there are 230 boat manufacturers of all types. Of these, fifty-two are reinforced plastics boat firms (25 in Ontario).

The section was pleased to welcome representatives of the Canadian Boating Federation, Allied Boating Association of Canada, the press, moulders and fabricators of boats to this meeting. Another honored guest was Bob Forger of SPE Executive Office, Stamford. Introduction was by Mr. John Biglow, Vice President of Sales at Reichhold.

Ontario

Plastics in Insulation

Harold A. Shure

The April, 1960 meeting of the Section took place at the Town and Country, Toronto. Seventy-eight people attended a lecture entitled "Plastics and Elastomers for Conductor Insulation and Jackets".

Mr. Barney Kellam, MA.Sc., P. Eng of the Ontario Hydro delivered this talk which dealt with the many considerations involved when an insulant or jacket must be selected from the plastics and rubbers available. Plastic and elastomer were defined with the two main differences indicated. These were the thermoplasticity of the resins and the thermosetting nature of the gums, and the elasticity of the rubbers. The factors common to both classes of materials that influences their characteristics were enumerated.

Philadelphia

Owens-Corning Fiberglas Plant Tour

George R. Dehoff

On May 24 the Philadelphia Section visited the Owens-Corning Fiberglas Plant at Barrington, New Jersey. Approximately 170 members and their guests enjoyed a splendid smorgasbord dinner at Schillig's Black Horse Farm after which chairman George Graf introduced the program for the evening. Mr. Haywood Drummond, guest speaker from Owens-Corning, introduced a film titled "The Magic Fiber" showing the production and use of fiberglas in reinforced plastics applications. Mr. Drummond then discussed the phys-

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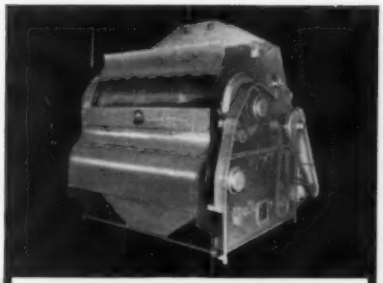

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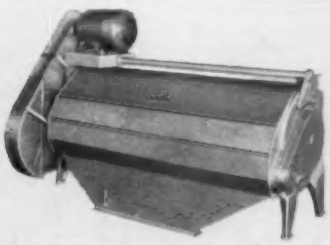

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ical properties of various types of glass fibers and fabrics and their applications. Two-thirds of the applications are in reinforced plastics. This segment of the plastics industry has shown tremendous growth during recent years and is expected to double in volume by 1965 compared to the 1959 production of 264 million lbs. Mr. Paoletti, Manager of the Barrington plant, then described the facilities and products made there. The plant tour followed and proved very interesting. Especially impressive were the automatic controls used in blending the raw materials and regulating the furnaces.

The Philadelphia Section was pleased to have Mr. M. A. Kohudic, editor of SPE Journal and Mr. T. A. Bissell, Executive Secretary of SPE, as their guests for this meeting.

Pioneer Valley

Blow Molding

Roger Johnston

An extremely well presented picture of blow molding and its future was given by Bob Boydon of F. J. Stokes Machine Co. on May 12.

There are two basic methods of making the tube; injection molding and the general method of extrusion. For extrusion there are three types of machines.

1. The tube is extruded continuously or intermittently from single orifice and the molds indexed into proper position before closing around tube.
2. The tube is extruded continuously from single orifice and molds are positioned around the tubing and closed while moving continuously away from the orifice.
3. A number of tubes are extruded continuously or intermittently from a manifold with a mold for each tube.

Inflation is by blowing through the extrusion mandrel or through a blow pin at the bottom of the mold or through a hypodermic needle with pressures of 20-3 p.s.i. The halves of the mold are clamped with pressures of 1-3 tons.

There is no generally accepted method of rating but probably the best is by size of the container produced. The design of an item must take into account the material, the size of the tube and the details of the bottle itself. Almost any hollow item can be blow molded. Molds are made from aluminium, kirksite, steel or beryllium but not epoxy.

The wide range of toys, housewares and industrial items that are presently being molded is ever expanding and even into the injection molding field. The range is limited only by the ingenuity of the molders.

Pittsburgh

Polycarbonates

C. A. Infante

Speaker for the May meeting was Paul Mitchell of Mobay Products Company. Paul was assisted by Dean Tyler, Mobay Product Sales Manager in the discussion of Mobay's new polycarbonate resin. A well-prepared slide assisted the talk which discussed basic chemistry, physical comparisons with other thermoplastics, applications, fabrication and competition.

Toledo

Student Night

Robert A. Davenport

The Toledo Section of the SPE held their annual Student Night on April 20, 1960.

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The Research Division of American-Standard has an opening for a Chemical Engineer in its Plastics Research Section. Applicants should have an advanced degree and be well grounded in the chemistry, structure and physical properties of polymers.

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Mr. Jim Hyland, 1959 Section president is the leader in student activity in our section. From this, a college scholarship fund has been set up for a deserving student interested in Engineering in the field of plastics. Therefore, for the past two years, the section has set aside one of its monthly meetings to entertain two students from each of the Toledo and area High Schools interested in Plastics. These students were chosen by their instructors in the schools.

The meeting was held at the Student Union Building at the University of Toledo.

A display was set up of various parts produced in this area showing Injection, Compression, and Transfer molded parts as well as Vacuum Formed parts. This was very well received. Members were on hand to answer questions pertaining to the parts and explain the advantages of the parts and the materials in them.

Twenty students and twenty eight members were present for the meeting.

St. Louis

Auto Plant Tour

Richard H. Koehrmann

The May meeting of the St. Louis Section of the SPE consisted of a plant tour of the new Chrysler assembly plant on May 16, 1960 where Plymouth, Dodge Darts and Valiant automobiles were seen being assembled. Approximately 50 members and guests made the trip. Dinner for the group was at the Holloway House following the tour.

Upper Midwest

Plant Tour and Lecture

Charles M. Smith

The Upper Midwest Section, SPE, wound up the 1959-60 season by touring Rainbow Plastics and Cosom Industries and attending a lecture on "Insulated Runner Systems" for molding polyethylene.

The plant tour was interesting and educational. Cosom Industries, who are adjacent to Rainbow Plastics, design new products and tools to make these products. Rainbow Plastics in turn mold and fabricate all products designed by Cosom Industries.

The lecture on "Insulated Runner Systems" was very well presented by Mr. J. N. Scott of Phillips Chemical Company. Phillips Chemical Company, according to Mr. Scott, have recently conducted experimental work on a new molding technique known as "Insulated Runner Systems". This technique utilizes the insulating properties of linear polyethylene to keep material in the runner system of a three plate mold in the molten state and at operating cylinder temperature. Because polyethylene has low thermal conductivity and high specific heat, temperature of the center core does not noticeably change even on large diameter runners.

Southern California

The Polyolefins Today

Irwin M. Zelman

A Panel discussion covering new developments in polyolefin technology was presented as the May meeting program to 125 members and guests of the SPE. The moderator, Milton Buck of L. H. Butcher Co., introduced the four panel members and explained that the fields discussed by the speakers were not exclusive with these men, but that each agreed to contribute pertinent facts in their assigned branches of the industry.

Frank Hughes, Dow Chemical Co. Technical Service, talked on the popular Low Density Polyethylenes, giving their properties and type differences.

Robert Lindegren, duPont Technical Service, traced the transition to the copolymer groups to utilize their superiority in some physical properties.

George Sollenberger, Koppers Co., began a discussion of High Density Polyethylene by answering the questions: "What do you look for in polyethylene?" "How do I select the right polyethylene?"

Paul Metzger, Hercules Powder Co., pointed out the superiority of the newest member of the group, polypropylene. With its specific gravity of 0.9 or slightly lower, it offers still higher heat distortion, no stress cracking, exceptional chemical properties and chemical resistance. Extrusion is more difficult than with ordinary poly, but the material holds high promise, particularly for sheet extrusion, because of its gloss, transparency and toughness.

Eastern New England Section
Regional Technical Conference (RETEC) . . .

New Horizons in Vinyls, and Plastics in the Shoe Industry

In recognition of rapidly increasing use of plastics in shoes and growing applications of vinyl plastics, the Eastern New England Section of SPE will sponsor a Regional Technical Conference (RETEC) covering both subjects on September 8 and 9, 1960, at the Statler-Hilton Hotel in Boston, Mass. The theme of the meeting—"New Horizons in vinyls, and Plastics in the Shoe Industry"—will be emphasized by the technical program comprising fourteen papers in four joint and concurrent sessions. These papers will cover vinyl applications in shoes and advanced vinyl technology as well as progressive methods of shoe construction.

The direct result of an extremely successful RETEC on "Plastics in the Shoe Industry" held in St. Louis last November, this RETEC will be held with the cooperation of the New England Shoe and Leather Association. Speaker at the Conference Luncheon on September 8 will be Francis H. Gleason, President of J. F. McElwain Company who will discuss "The Shoe Industry and Technological Change". George W. Martin, SPE President, will also summarize current and future Society activities in his address entitled "The Progress and Future of SPE".

The RETEC which is under the Chairmanship of Gim P. Fong of Raytheon Company is expected to draw a substantial number of registrants from all parts of the country as well as from the New England and New York areas.

September 8-9, 1960 • Statler-Hilton Hotel • Boston, Mass.

Technical program developed by a Committee under the Chairmanship of Robert A. Abeles of Elfskin Corporation is as follows:

September 8

8:00 to 9:30 a.m. —Registration

Joint Session —Vinyl Applications in the Shoe Industry

9:30 a.m. —**INJECTION MOLDING APPLICATION FOR THE FOOTWEAR INDUSTRY**
Gordon Cooper
International Vulcanizing Corporation

10:00 a.m. —**'PORON' MICROPOROUS PLASTIC INNER SOLE**
Benjamin B. Levy
Rogers Corporation

10:30 a.m. —**COMPARATIVE COATED FABRICS**
Robert Abeles
Elfskin Corporation

11:00 a.m. —**COMPARATIVE FOAMS**
(Speaker to be Announced)

11:30 a.m. —Discussion of Morning Papers

12:00 —**RETEC Luncheon**
Speakers
The Progress and Future of SPE
George W. Martin, SPE President

The Shoe Industry and Technological Change
Francis H. Gleason, President
J. F. McElwain Company

Concurrent Sessions

PLASTICS IN SHOES		ADVANCED VINYL TECHNOLOGY
RECENT ADVANCES IN LEATHER TECHNOLOGY AND HOW THEY AFFECT SHOE MANUFACTURING Eugene Black Paule Chemical Corporation	←2:00→ p.m.	**APPLICATIONS OF CONDUCTIVE VINYLS** J. Parker Abbey Plastics
RECENT DEVELOPMENTS IN VINYL ADHESIVES FOR SHOES J. R. Carey Compo Shoe Machinery Corporation	←2:30→ p.m.	**THE EFFECT OF PLASTICIZER ON PLASTISOL FUSION** Paul R. Graham & J. R. Daby Monsanto Chemical Company
COMPARATIVE MOLDING ON SOLES Frank Remmes Randolph Machine Company	←3:00→ p.m.	**STABILIZING PLASTIC AGAINST ULTRAVIOLET DEGRADATION** F. R. Hansen & R. A. Buckley Ferro Chemical Company
To Be Announced	←3:30→	To Be Announced
Discussion of Afternoon Papers	←4:00→ p.m.	Discussion of Afternoon Papers

September 9

Joint Session —Progressive Thinking in Shoe Construction

9:30 a.m. —**HARD VINYL HEELS FOR THE 'FLATTY SHOE'**
Robert Dukeshire
Goodyear Tire & Rubber Company

10:15 a.m. —**DIRECT MOLDED FOOTWEAR (Movie)**
L. G. Cappiello
U. S. Shoe Machinery Corporation

11:00 a.m. Open Forum

11:45 a.m. Adjournment

For advance registration contact Dominick V. Rosato of Raytheon Company, P. O. Box 25, Maynard, Mass.

ABOUT MEMBERS

Ronald L. Rasmussen has been appointed Assistant Regional Manager, South Atlantic Region of Union Carbide Plastics Co. His headquarters will be in the company's Moorestown, N. J., office.

◄ Mr. Rasmussen

William E. Grigsby heads a new organization to consolidate and extend long range research activities at the Du Pont Co. Research work related to the established plastics business will be carried out by a unit headed by **William A. Franta,** as director of plastics research and development. Announcement of the reorganization was made by **Frank C. McGrew,** director of the Polychemicals Department's Research and Development Division.

Charles A. Heiberger recently joined Air Reduction Co. as Assistant Director in charge of Polymer Development and Application. Dr. Heiberger was formerly associated with Food Machinery and Chemical Corp.

Costas H. Basdekis has been promoted from senior group leader to assistant research director for polystyrene, Monsanto Chemical Co., Plastics Division. Also for Monsanto, **Leo P. Paradis** was promoted to group leader of a newly formed polystyrene product development group.

Richard J. Thompson has been appointed Manager of Polycarbonate market development in General Electric Company's chemical materials department, Pittsfield, Mass. Mr. Thompson is a graduate of Penn State University.

David Hancock, former director of research and development for Chippewa Plastics, Inc., has been named president and general manager of a new company—Applied Research and Development Corp. The new company specializes in extruded expandable polystyrene foam and film. Mr. Hancock will be located at 210 E. Columbia St., Chippewa Falls, Wis.

T. Earl Dudney has been named to head the Leominster, Mass. sales office of the plastics div., Eastman Chemical Products, Inc. Eastman Chemical also appointed **John T. Moore** assistant sales manager and **John Adams** manager of polyethylene sales development.

William F. Christopher is director of marketing for Hooker Chemical Corp., New York City. Mr. Christopher comes to the newly created position from General Electric Co., where, since 1955, he was manager of market development in G E's Chemical Materials Department.

◄ Mr. Christopher

M. F. Antonovich has been promoted to the position of General Purchasing Agent, Harchem Division, Wallace & Tiernan, Inc. Mr. Antonovich has been with Wallace & Tiernan since 1957 and before that was with Advance Solvents & Chemicals for 27 years.

Mr. Antonovich ►

R. A. Clarke goes to Plastics Division, Reynolds Metals Co., Grottoes, Va., as research director. He was formerly at the Battelle Memorial Institute. **Charles A. Wales,** formerly of the Texas City plant of Union Carbide Chemicals Co., has been appointed a superintendent of the Bound Brook (N. J.) plant of Union Carbide Plastics Co.

Lloyd T. Moore has been named sales manager of Libbey Plastics, Inc., Lake City, Pa. Mr. Moore will devote his full time to development of sales of the company's melamine dinnerware products and the possibility of making other plastic products in the Lake City plant.

Dow Chemical Co. has announced acquisition of exclusive worldwide rights to commercial development of "plastic smoke" from the inventor, **Miss Betty Lou Raskin,** research associate at the Johns Hopkins University Radiation Laboratory, Baltimore, Md. Miss Raskin is a member of the Baltimore-Washington Section.

Milton A. Sanders, Joseph L. Banano, and **Robert Bartlett** were honored by the Newark College of Engineering at graduation exercises last month. They received the College's 75th anniversary award for their activities in establishing a plastics education program which has been receiving national and international attention.

Robert B. Bennett has been asked by the Universidade de Minas Gerais, Belo Horizonte, Brazil, S.A., to teach and conduct research in chemical engineering for two years. Dr. Bennett has been asked to use his 17 years of industrial experience in plastics and 7 years of teaching and research as Professor of Chemical Engineering at the University of Florida, to assist in teaching related subjects, as well as assist in operating a new Triga reactor.

Edmund H. Merz has been appointed director of the Materials Formulation and Evaluation Department of the General Packaging Research and Development Division, Continental Can Co. Dr. Merz comes to Continental Can from Monsanto Chemical Co.

Dr. Merz ►

NEW BOOKS

POLYESTER RESINS

John R. Lawrence (Reinhold Publishing Corp., 246 pp., $5.75).

This book is an excellent brief review of unsaturated polyester resins. The author states in his preface, ". . . the book is intended to serve as a guide to those directly or indirectly associated with fabricating or using articles fabricated from polyester resins." The book fills this purpose admirably.

The present book is one of the Reinhold series on plastic materials and covers the areas of chemistry, properties, manufacture, and applications of polyester resins. These discussions are well handled and easily understood.

The appendix on commercial resins and properties deserves mention. The need for special resins for each application has led to a multitude of resins. Organization and presentation of this information is certainly of value to all in the polyester resin field.

The only serious fault of this volume is that the footnotes are not as complete as they might be. Any book on polyester resin chemistry will be compared with "Polyesters and Their Applications" (Bjorksten Research Laboratories) which has 3200 odd references. The Lawrence volume is entirely too brief in many areas. The recommendation for technically trained readers is still the Bjorksten book. Much more detailed information is presented therein.

This reviewer would have presented the information on chemical resistance in a different manner. No data is presented on resins based on isophthalic acid, bisphenol A, or hydrogenated bisphenol A which have superior chemical resistance in some areas where conventional polyesters fail quickly. The author implies improvements can be made but the magnitude of improvements warrants a fuller statement.

Robert E. Park
Pittsburgh Plate Glass Co.

ADVANCED ANALYTICAL CHEMISTRY

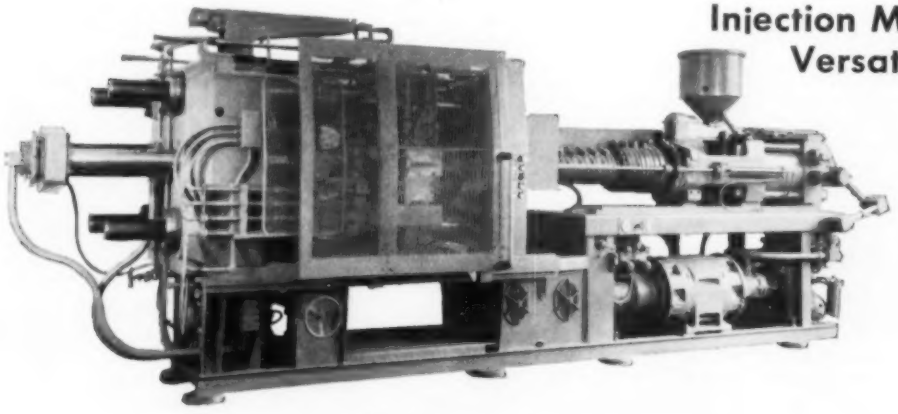
Louis Meites and Henry C. Thomas (McGraw Hill Book Co., Inc., New York 1958, 540 pp., $9.50)

This book is divided into 12 chapters dealing with the following subjects: generalities, ionic equilibria, potentiometry, pH, conductometry, polarography, electrolysis, light absorption, radiochemistry and chromatography. The chapter on Infra-Red absorption is written by Robert P. Bauman.

In each chapter, the reader will find problems, the solution of which will be found at the end of the book, together with an appendix and a great many practical experiments. There is an abundance of tables, graphs and illustrations which contribute to make this manual very easy to read.

It seems to us to contain the essentials of modern analytical chemistry, and as such, is recommended to all chemists whether in training or seasoned. Several chapters as, for instance, chapter 11 on ion exchange will be of particular interest to plastics chemists and engineers.

Dr. Louis C. Barail
Barail Associates



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DEVELOPMENT ENGINEERS

NRM has exceptional opportunity for top-quality project engineers. Substantial experience in blow molding or extruder design can lead to rapid advancement. Please send resume of education, experience, and salary requirements to E. E. Heston, Manager, Extruder Division, NRMC, 47 W. Exchange Street, Akron 8, Ohio.

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Medium sized successful manufacturing firm in Mid-west desires man with experience in techniques and design in Blow Molding. Excellent opportunity for right man to grow with an expanding company entering this new field. Box 6860, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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Mechanical or electrical engineering degree desirable. Product design of a wide variety of metal fastenings, injection molded plastic parts, small mechanism, etc. Considerable opportuniy for individual having creative ability. Patent background desirable, but not essential. Box 6160, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PLASTICS SALES ENGINEER

We are building an organization to commercialize the new plastics being developed by our research program. We need an effective and aggresive sales engineer to help introduce our materials to customers. Ability to work with product designers, plastic specialists, molders, extruders, and purchasing agents essential.

Five to ten years experience with thermoplastics, their molding, extrusion, and fabrication desired. Preferably includes acrylic background.

This is a position of major responsibility offering high challenge and excellent opportunity for a rewarding future.

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Personnel Manager
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Experienced as a key executive of a manufacturing facility engaged in the production of plastic materials.

Excellent background in Finance, Sales, Purchasing, Production and Plant management.

Accustomed to full responsibility, age 31, B.S. Degree.

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Fourteen years diversified plastics experience in development, technical service and production of FRP, filament winding, epoxy, phenolic and melamine laminates. Presently owner of own business. Salary area—$12,500. Desire responsible position with progressive plastics firm. Any location. Reply: Box 6360, SPE JOURNAL, 65 Prospect Street, Stamford, Conn.

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Employed plastic sales development work Detroit automotive industry.

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PLASTICS ENGINEER-ADMINISTRATOR

Over ten years experience in plastics. Last five in R & D administration. Considerable experience in extrusion, particularly in polyolefins but also with most other plastics. Have good knowledge of injection molding, blow molding, calendering, laminating, embossing, heat sealing and film orientation. Have worked on process development of both thermoplastics and thermosets, also on rheological studies of many materials. Some knowledge of market research.

Desire responsible position with good future. No geographical limitations. Box 4560, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

DEVELOPMENT ENGINEER

Young management qualified process/product development engineer with excellent experience in plastics development and production desires responsible position with progressive company. Chemical background as Technical Coordinator in extrusion compounding, coating application development and production. Box 4960, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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17th ANTEC

Annual Technical Conference—January 24-27, 1961, Shoreham and Sheraton Park Hotels, Washington, D.C. Sponsored by the Baltimore-Washington Section. General Chairman: Dr. Gordon Kline, National Bureau of Standards, Washington, D. C.

1960 RETECS

September 8 and 9—New Horizons in Vinyls and Plastics in the Shoe Industry, Eastern New England Section, Statler-Hilton Hotel, Boston, Mass. Co-Chairman, Program, Robert Abeles, c/o Elfskin Corp., Main St., Cherry Valley, Worcester, Mass.

September 22—Plastics in Business Machines, Binghamton Section, Sheraton Inn, Binghamton, N. Y. Chairman; John E. Gwyn, c/o Consolidated Plastics, 498 Conklin Ave., Binghamton, N. Y.

October 5—Plastics in Corrosion, Golden Gate Section. Chairman: J. W. Richardson, c/o Rohm & Haas Co., 600 California St., San Francisco 8, Calif.

November 7—Automation in Injection and Compression Molding, Ontario Section; location: King Edward Sheraton Hotel, Toronto. Chairman: J. M. Lees, c/o Canadian General Electric Co., 755 Division St., North Cobourg, Ontario, Canada.

November 18—Blow Molding, Newark Section, Essex House, Newark, N. J. Chairman: Robert Hoehn, Mack Molding Co., Ryerson Ave., Wayne, N. J.

1961 RETECS

April 25, Indianapolis, Ind., Central Indiana Section: **Plastics for Tooling.** Section President: Milton Brummer, 4241 Marrison Place, Indianapolis, Ind.

May 9, Detroit, Mich., Detroit Section: **Plastics in the Automotive Industry.** Section President: Gordon Thayer, Dow Chemical Co., Plastics Technical Service, Midland, Mich.

October, Niagara Falls, N. Y., Buffalo Section: **Foams.** Section President: William Dunmeyer, Carborundum Co., Buffalo Ave., Niagara Falls, N. Y.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to Section Presidents, as indicated above.

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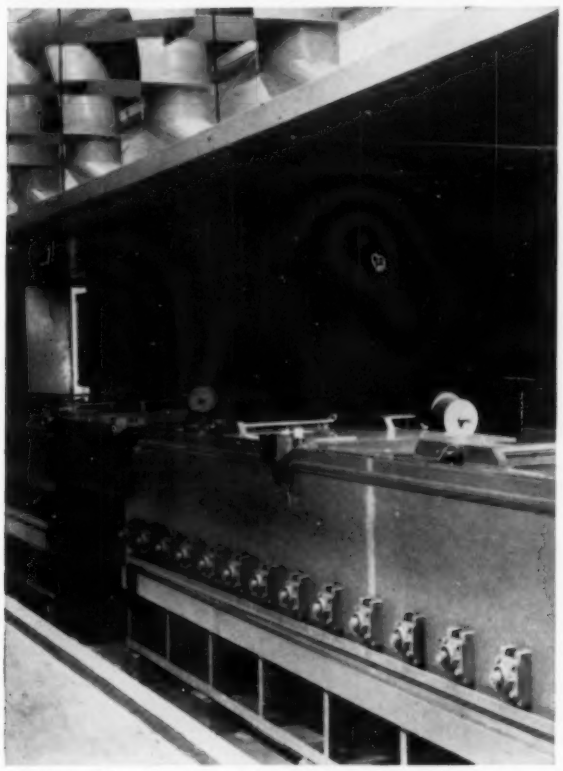

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